HARDWARE OF MANUAL ASSEMBLY WORKSTATION ON-LINE ANALYSIS

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There are various methods and tools that can be used to increase the assembly workstation quality and productivity. The paper describes the concept and hardware of on-line assembly workstation analysis. This analysis is based on using the sensors with defined obtainable information. The presented concept allows for obtaining data and transferring them to a computer for analysis in real time. After finishing and testing, this concept will provide a modular analytical tool for manual assembly workstation analysis from the point of view of time, failure, etc. The presented approach also enables to process the data obtained from other sources such as a peripheral unit, software or video analysis. It provides consistent method of manual assembly workstation analysis also in the phase of assembly workstation design, when only a workstation 3D model is available.

Keywords: on-line analysis, manual assembly, workstation, sensors

1. Introduction

Modern approaches in manufacturing and assembly technologies [1] are oriented inter alia in the CAx support [2], simulation [3] and in structure planning. Most of them are realized for the purpose of increasing the productivity and quality. Nowadays all modern manual assembly workstations are equipped with sensors that monitor and control the assembly process [4]. They are assigned also for proper assembly process execution, for checking of prescribed assembly operation parameters, for obtaining information about the state of checked equipment, blocking the execution of operation in the event of a fault or incorrect parameter settings, incorrect tools, fixtures etc. These sensors are a part of a complex assembly workstation and serve primarily to ensure the quality of the final assembled products. When they are used for the assembly process analysis and evaluation then special software designed just for this particular application will be created. Among various assembly workstations there exist great differences and it is very difficult to obtain a universal basis for the analysis and

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evaluation. Due to the above mentioned reasons there arose a need to propose a system that can eliminate these differences. Another reason is the need to analyze the assembly procedure of different products in laboratory conditions at a modular assembly workstation. The main requirements for such a method include in the first place the independence from the assembled product and specific sensors installed at the workstation. The analysis must be also independent from types of assembly workstations and their interactions. The suggested system should be also entirely independent from a specific workstation control system.

2. Concept of assembly workstation on-line analysis

The concept of on-line manual assembly workstation analysis is based on obtaining the information from sensors installed at a manual assembly workstation. In case there are no sensors installed at the assembly workstation, other inputs which give the same information about the assembly process can also be used. The on-line analysis is in fact based on obtaining answers to five basic questions – information from the first five sensors:

- is the product present at the assembly workstation?
- has the assembly begun?
- has the assembly process ended ok?
- has the assembly ended?
- has the assembled product left the workstation?

The maximum number of sensors at one workplace is 10. The first 5 sensors that give the answer to the above mentioned questions are mandatory, the others are optional. The other 5 sensors give information about the state of the selected devices or assembly process execution and this system can either immediately stop the whole assembly system or wait for a defined time dedicated for the identified error remedy. If the manual workstation is equipped with sensors for assembly control the appropriate sensors can be selected and their signals can be used also for the on-line analysis. In the case that the sensors are not installed in the manual workstation, the workstation can be additionally equipped with sensors only for the purpose of the on-line analysis. The third possibility is a combination. The concept includes a maximum of 5 workstations linked together (see fig. 1). The main characteristics of this system are:

- modular structure,
- universal usage,
- possibility of further upgrade,
- possibility of incorporating the on-line analysis into the complex procedure,
- variant usage of the obtained data.

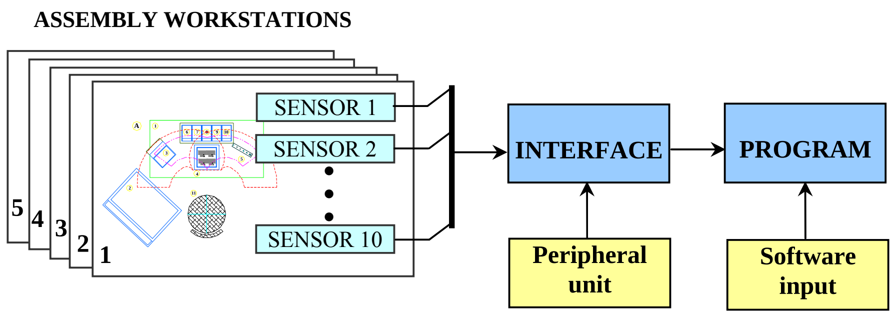

Fig.1. The concept of manual assembly workstation on-line analysis

The proposed system is designated for individual or joint assembly workstations involving a sitting or standing worker position, for small or middle size products, with the number of assembled parts being up to about 50 pieces (e.g. pump, buffer cylinder, etc.).

3. Hardware

To realize a functional on-line system, two hardware units are essential. The first one is an interface assigned for the processing of sensor signal. The second one is a peripheral unit created for signal input provided in a different alternative way. This unit just substitutes the sensors installed at the workstation. There is also a possibility to obtain input signals from other sources, such as a software module that simulates sensor input or Assembly Operation Analysis software [5] for video analysis.

Output data can be obtained in three different ways. The first one is constituted by the on-line outputs in real time. The second one is the information obtained as a summary report processed according to defined requirements after the assembly process has ended. The last one is the information about analysis realized in the past and saved in the system.

4. Interface

The interface is an important part of the whole on-line analysis system. Its main task is constituted by reliable reading of signals from sensors installed in the assembly workstation, signal modifications and their subsequent sending into the computer for further processing.

There are two main personal computer related problems that have to be solved to connect a sensor:

- incompatibility of sensor signals with PC input,
- the number of sensors is higher than the number of input lines of PC port.

The presented aspects show the necessity to decrease the output voltage to the maximum level allowed for the input parallel computer port, e.g. 5V. The voltage reduction will be realized by a simple circuit presented in Fig. 2. Resistor Rz decreases the sensor signal output current and the diodes D1 and D2 “cut” the output voltage to the level within the range of 0…5V. Consequently, the modified signal can be processed safely by further electronic circuits.

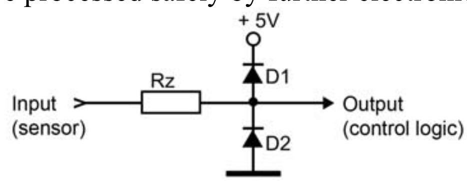

Fig.2. Wiring scheme of sensor signal modification

The next problem resides in the connection of a greater number of sensors to a limited number of lines of a computer input parallel port. The developed system of on-line analysis takes into account the connection of 5 workstations and a maximum of 10 sensors in each one, which means processing of 50 sensor signals. In its basic configuration the computer has 5 parallel port input lines. To connect all of these sensors the sensor signals have to be multiplexed.

Will be used one computer parallel port input line for sensor signals reading and the signals from particular sensors will be sent in sequence to the computer. This activity will be executed several times per second. The given cycle is sufficient for the requirements.

The integrated circuits – multiplexers are standard produced in a configuration of maximum 2, 4, 8 or 16 inputs. This means that signal processing from 50 sensors will require several multiplexers and another control electronics that will ensure the selection of the required multiplexer in a specified time. The complex block diagram of the processing of all sensor signals is presented in Fig. 3.

By the computer parallel port output lines and appropriate interface control electronics will be select one required multiplexer (one workstation). Then the sensors of appropriate workstation will be read. Each signal will be modified by the input circuit and will be sent via multiplexer and an auxiliary logical circuit to the input line of computer parallel port. Demultiplexer switches the following activity to the next multiplexer that reads the sensor signals from the next workstation. This activity is repeated several times per second.

The complete interface is placed in a plastic cover (see fig. 4). The power switch and a diode that signalizes interface activity are located in the front panel. The power supply cable, computer connecting cable and 5 connectors for bus wire connection are arranged at the backside. Each connector is assigned for a connection of one workstation with the maximum of 10 sensors.

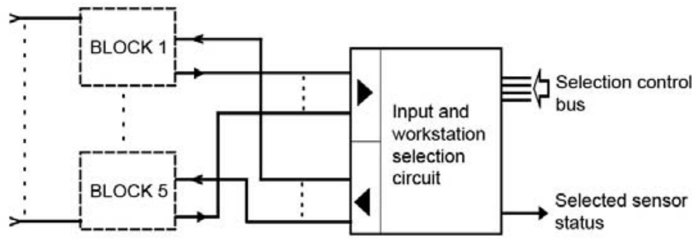

Fig. 3. Block scheme of interface unit connection

5 connectors for connecting of 5 assembly workstations

Fig.4. Interface unit

The electronic wiring enables to expand the connection to 16 sensors for every workstation by using all multiplexer inputs and to increase the workstation number up to 10 by using of all demultiplexer output lines. In case of using a 16-bit demultiplexer, the number of workstations can be extended to 16. So the maximal number of sensors can be up to 256. The fig. 5 shows the interface-wiring diagram.

5. Peripheral device

In order to use the on-line analysis system also without a connection to real assembly workstation, a peripheral device was developed [6].

The peripheral device is connected to the interface instead of the sensors placed at assembly workstations. The peripheral device output provides the same output signals as the sensors from the point of view of hardware. There is only one difference. It is not necessary to decrease and modify the peripheral device return signal because this signal is adapted according to the interface requirement, e.g. 0V or 5V. The connection of peripheral device is simple. There are standard switch buttons with outputs, which are additionally treated against inaccurate pressing and overshooting. The simplified peripheral unit wiring diagram is presented in Fig. 6.

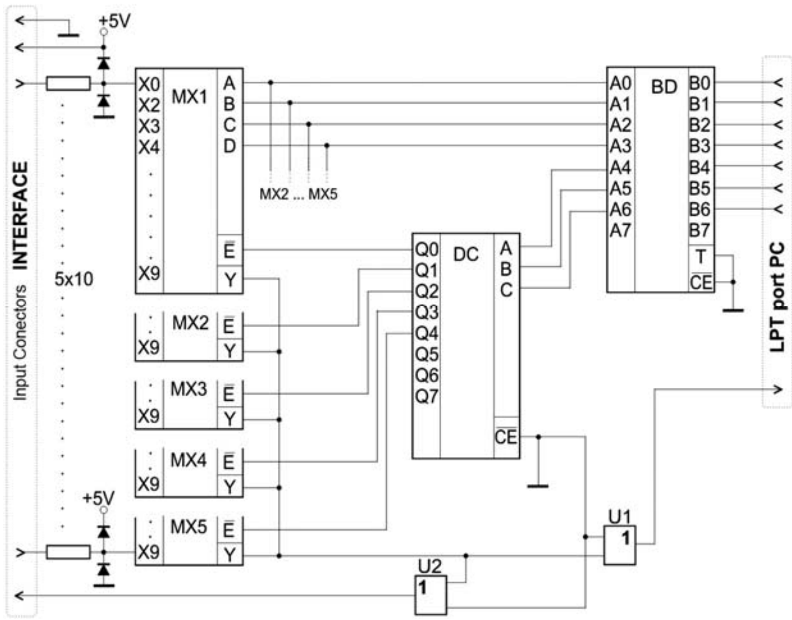

Fig.5. Interface-wiring diagram

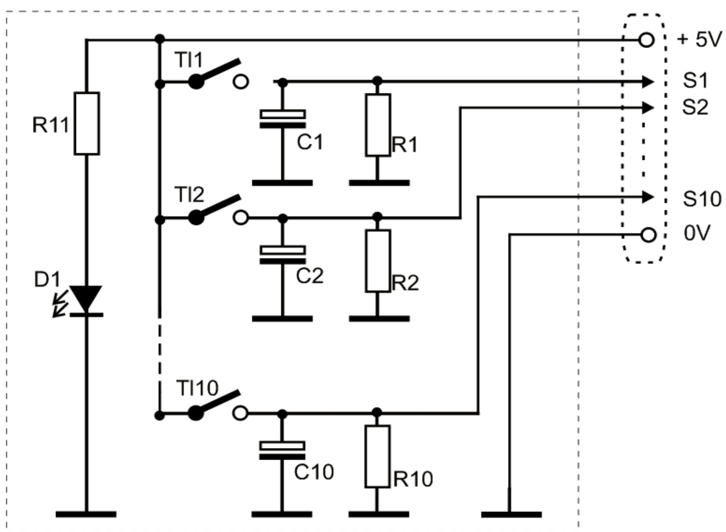

Fig.6. Peripheral unit wiring diagram

6. Other components

An important component and a requirement to enable the connection with a personal computer is a free parallel port in the computer. The parallel port must be set to the SPP mode (Standard Parallel Port) or to the EPP (Enhanced Parallel Port). In case the computer does not have its own parallel port, the computer can be supplemented by a card with a parallel port. .

7. Results

The mentioned hardware units have been realized and their function verified at a common personal computer. The second step in solving this task was the development of appropriate software tool using Microsoft Visual Basic: NET programming language in the Microsoft Visual Studio 2008 development environment.

The first results indicate both the interesting application possibilities and a possibility of variant usage. A 3D model of a manual assembly workstation with a planned arrangement of 5 main sensors (s_1 to s_5) required for the on-line analysis is presented in the fig. 7. The sensor type is not significant for this analysis. Either a peripheral unit or a software input can be used for assembly process analysis. Development of a new analytic software module based on the same philosophy as the presented on-line analysis is also considered in this context.

The signal from the installed sensors will be used in a real assembly process. The future direction of the development can reside in the use of various data sources (sensors, peripheral device or software) for the same assembly process. This can bring interesting results that have to be carefully analyzed and interpreted.

8. Conclusions

The presented solution is based on the existing trend in manual assembly workstation design including sensors. The sensors placed in a manual assembly workstation, which are initially used for assembly process control, can also be used for assembly process analyzing, monitoring and evaluation. The developed concept and tool can be used for assembly process monitoring, evaluation and analysis for all purposes that correspond to the defined range of application. The presented method is now in the phase of final practical testing, especially with respect to the software tool. The presented hardware part is fully functional and its development can be considered as accomplished.

In relation to this concept a software solution that can cooperate with results obtained from video analysis realized by software AOA (Assembly Operation Analysis) will be developed.

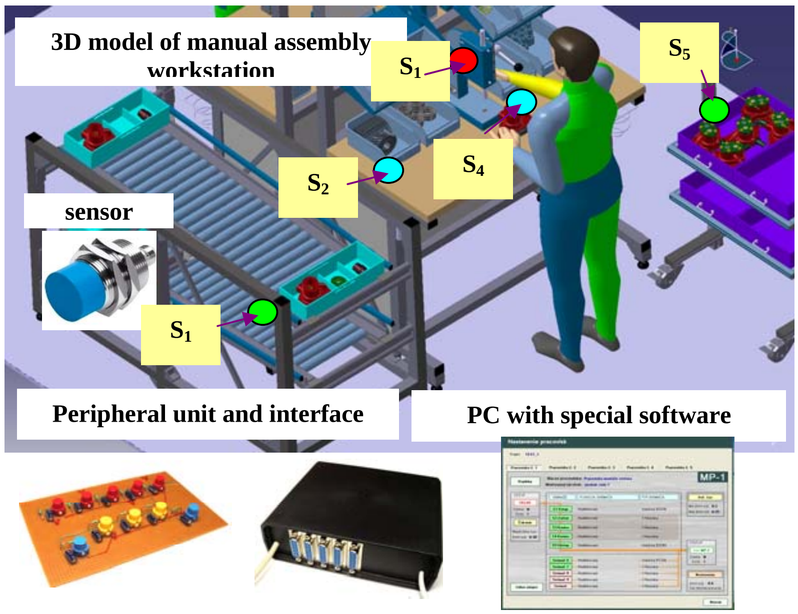

Fig.7. Principle of the on-line analysis based on assembly workstation 3D mode

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