Automatic System for Handling Fragile Objects

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Abstract: *The paper presents an automatic handling system made on a small scale. The entire structure is integrated in an electro-pneumatic drive. The handling of fragile objects is done using vacuum technology. The system is controlled by a PLC in accordance with the required operating protocol.*

Keywords: *Handling, automatic system, PLC, electro-pneumatic drive, vacuum technology*

1. Introduction

The technique of handling calls means or devices, which carry the flow of material from one post to another. One of the most important problems of industrial production automation is the transition from handling performed by the human operator to automatic handling [1].
The problem of developing standardized equipment systems for automatic handling of parts has become in recent years the main concern of global companies with technology concerns.
The advantages, qualities and flexibility of the pneumatic drives, the facilities offered by the interface elements have allowed a rapid improvement and adaptation to the new requirements imposed by the specifics of the processes in which they are integrated [2].
The rapid paces of technology development and advances in electronics have today enabled the development of highly efficient drive equipment and a high degree of "intelligence" built into it. Thus, the main direction of current research is to improve the control of pneumatic drives by incorporating "intelligence" [3].
Robots and manipulators are the most complex and flexible machines that have been created and used by man so far that incorporate pneumatic drives [3].
The handling of fragile parts based on vacuum technology ensures increased productivity offering maximum durability and functionality with a light, compact and robust design and the possibility to be used in any industry [4].
Taking into account these considerations, the paper presents an automatic system for handling fragile objects using a vacuum technology.

2. Structure of the handling system

The proposed automatic fragile object handling system consists of a stock of fragile plates at the entrance, an output stock and a manipulator system that transfers the plates to be processed from the input stock to the output stock (Fig.1).

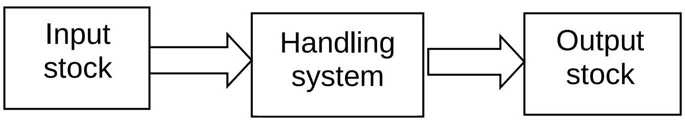

Fig. 1. Structure of handling system

Starting from the previously presented structure of the fragile object handling system, it is proposed to create a manipulating system that performs the handling operation for a single piece per work cycle, and the input stock has a capacity that can include several fragile plates.
The entire structure is integrated in an electro-pneumatic drive system with linear (pneumatic cylinder) and rotary (electric motor) actuators, controlled by monostable and bistable valves [5],[6].

The block diagram of the handling system is shown in Fig. 2.

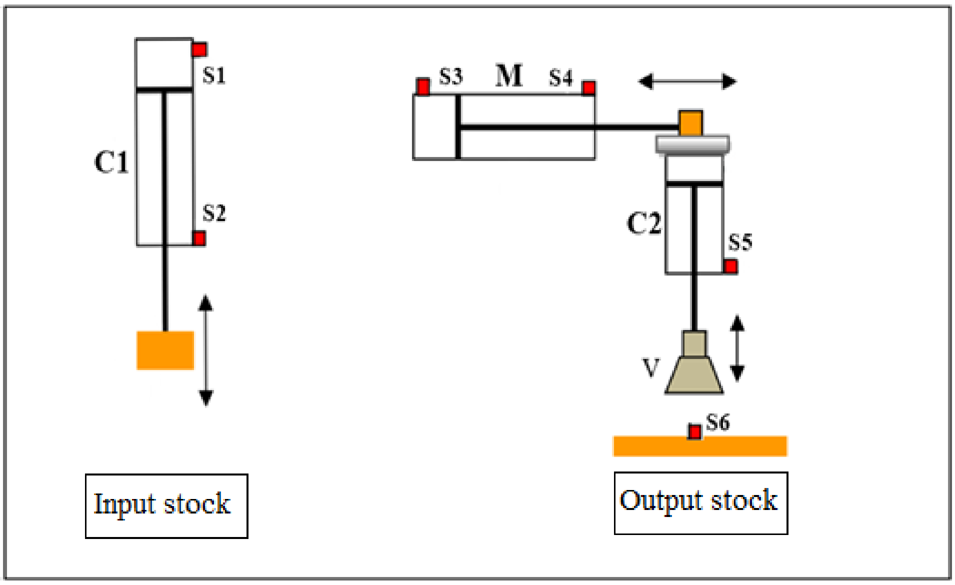

Fig. 2. Block diagram of handling system

Based on the structure of the pneumatic drive, general scheme of the automatic handling system (Fig. 3) was carried.

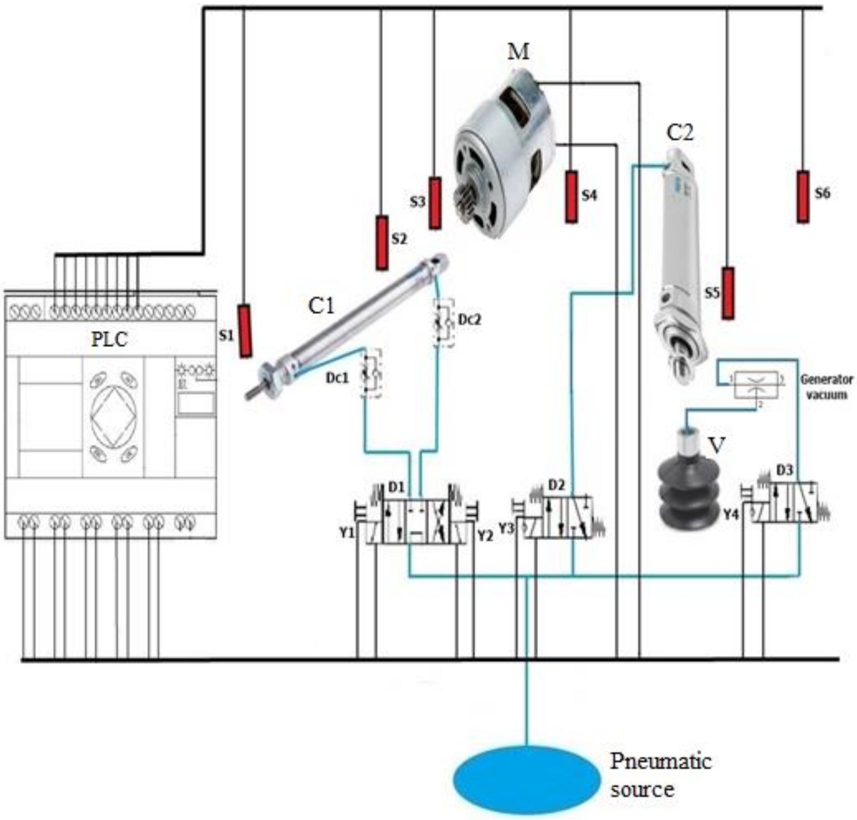

Fig. 3. Schematic diagram for the interconnection of the elements of the handling system

The meaning of the elements used in the scheme is as follows:
PLC - programmable logic controller;
D1...D3 – pneumatic valve;
C1, C2 – pneumatic cylinders;

M– electric motor;
DC1...DC3 – one-way flow control valve;
S1...S6 – sensors;
Y1...Y4 – relays valve control;
V - vacuum suction cup.

3. Modeling and simulation of the handling system

The pneumatic drive is modelled and simulated on a personal computer using the Festo FluidSim Pneumatics application [7], [8].
The modeling of the pneumatic actuator consists of two parts: shaping the power (pneumatic) part and shaping the electrical and control part. Both parts of system modeling mainly involve choosing components in the Component Library, placing them on the design sheet, setting parameters, and making connections between components [8].
If the component library is not visible in the workspace, it can be displayed by choosing Total View from the Library menu.
The model of the pneumatic part of the processing station was divided into two blocks (Fig. 4):
- the compressed air preparation unit block;
- the block of the handling system.
It is mentioned that the electric motor M in the handling system structure is replaced with a pneumatic cylinder C1.

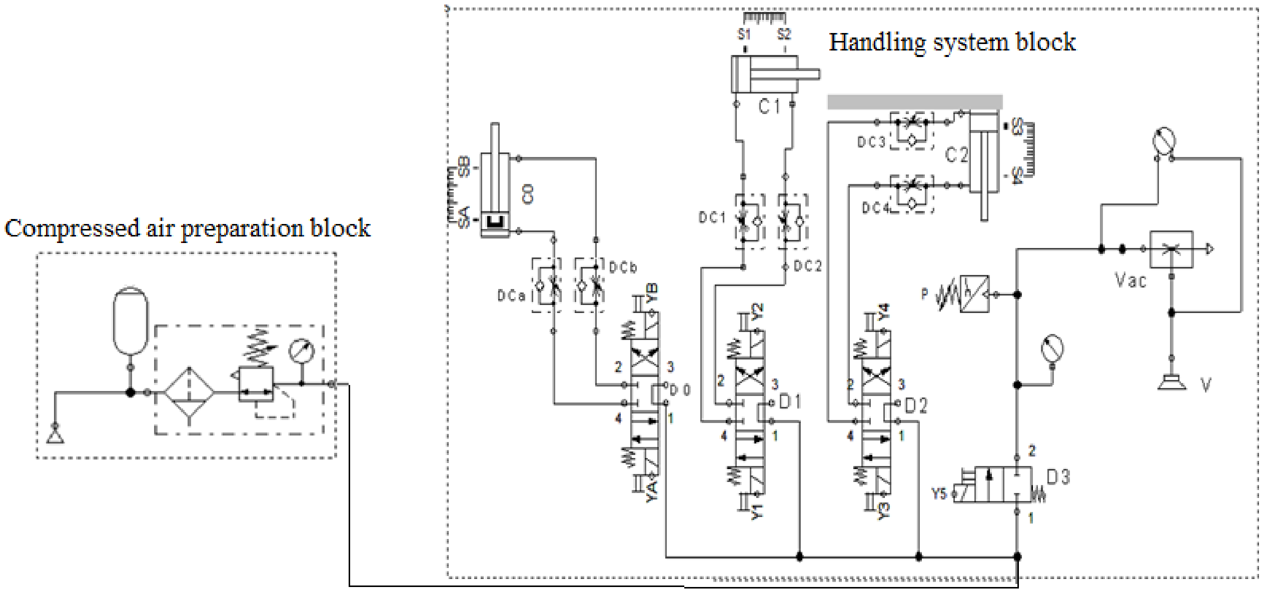

Fig. 4. FluidSim model of the handling system

A complete working cycle of pneumatic drive involves following sequences:
Stage 1:
Advance C0→Retraction C0→Advance C2→vacuum suction cup V is ON.
Stage 2:
Retraction C2→ Advance C1
Stage 3:
Advance C2 → vacuum suction cup V is OFF
Stage 4:
Retraction C2 → Retraction C1.
For simulation results, FluidSim can generate a state diagram of pneumatic drive [8]. The state diagram records the state quantity of important components and depicts them graphically (Fig. 5).

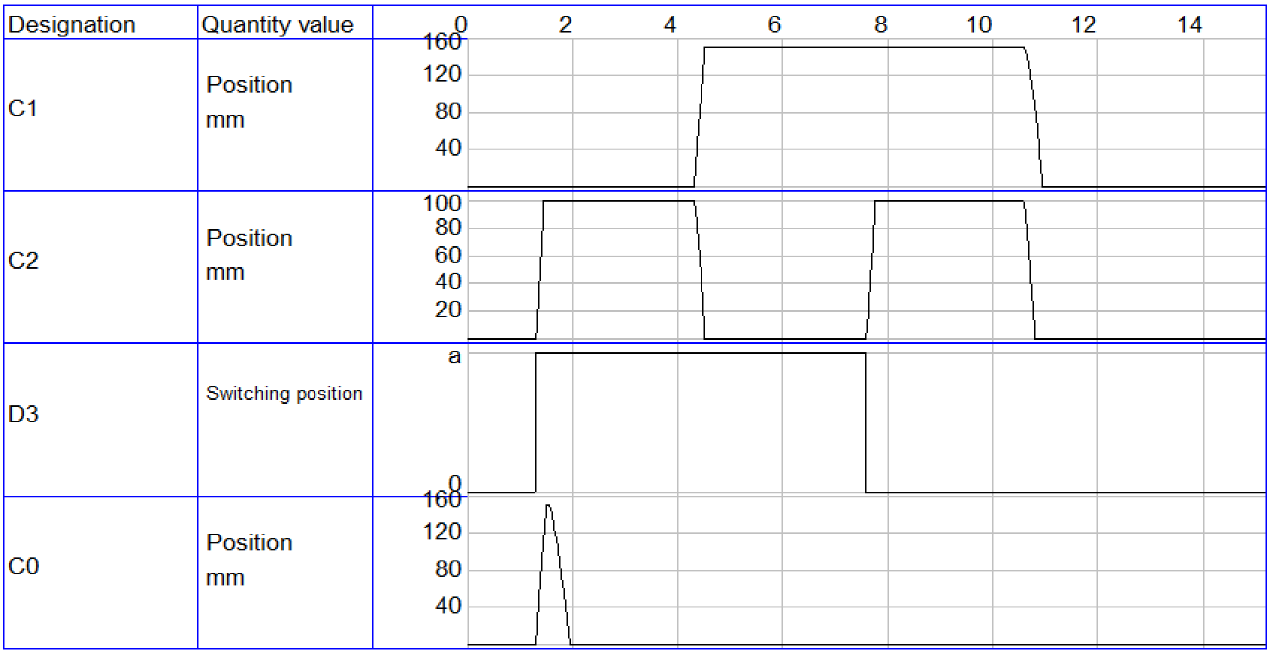

Fig. 5. State diagram of pneumatic components, in a work cycle generated by FluidSim

The status diagram is very useful for tracking and analysing the operating cycle. Based on this, anomalies, defects, irregularities in the operating cycle can be identified. Optimizations of the handling process can also be made.

The state diagram highlights the operating sequences of the execution elements in the pneumatic drive. These diagrams show the correct operation of the handling system.

4. Achievement of the automatic handling system

4.1. Achievement of the control system

The following aspects were taken into account in the implementation of the control system:
- simplifying the hard drive and using as few components as possible;
- the possibility of easy system programming.

To meet the above requirements, a PLC control system has been designed. For this purpose, the Eaton Easy AC-RC-719 programmable controller was selected [9], [10].

It offers a number of facilities including:
- small size;
- direct power supply to the 220V network;
- Keyboard and screen presence;
- a total of 14 entries.

If the Eaton Easy AC-RC-719 PLC is connected to a PC, then we can use the EASY-SOFT program. It will allow the creation and testing of the circuit on the PC, as well as the printing of the diagram made in the Ladder in DIN, ANSI format or in the own format generated by the software [9].

4.2. Achievement of the power and protection circuit

The Eaton Easy PLC is powered directly from the 230V 50Hz AC mains. A 24V DC source is required for the application to operate, as the coils of the 3 distributors, the relays and the sensors used operate at a voltage of 24V. Figure 6 shows the electrical circuit diagram of the handling system.

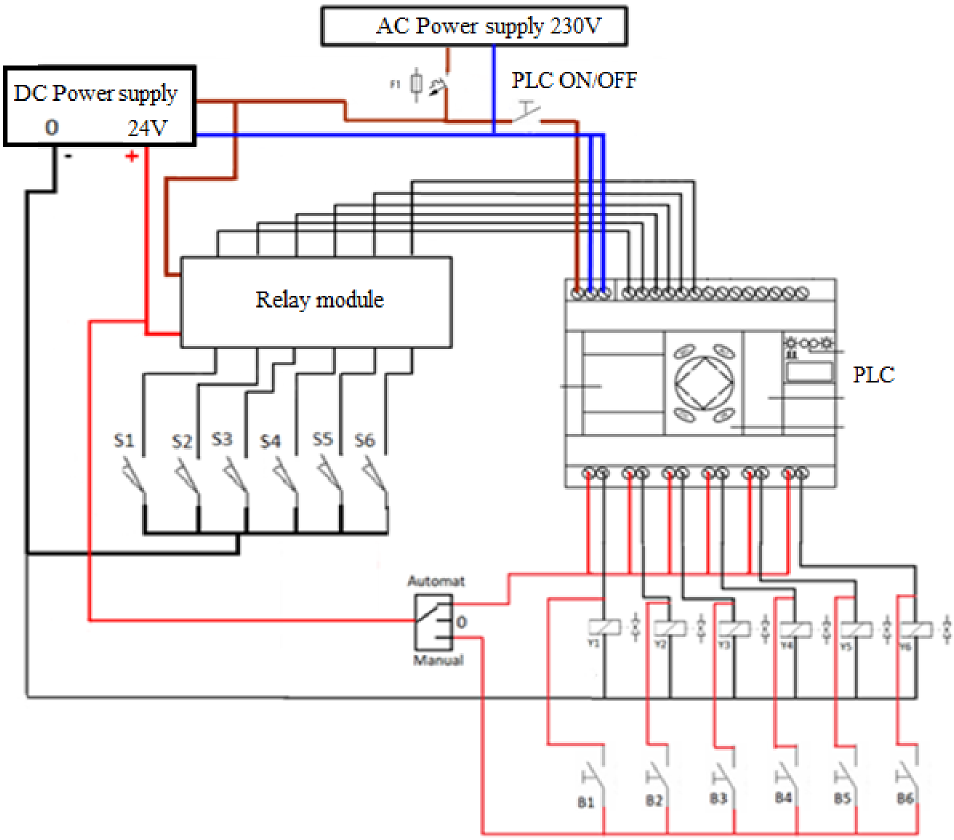

Fig. 6. Electrical circuit diagram of the handling system

4.3. Achievement of the user communication system

At the core of the control process there is the command and control unit that manages the entire process as well as the human-machine interface [11].
Based on the operating principle of a closed-loop control system [12], [13], the command and control unit takes over the position information of the system sensors from the position sensors and the presence piece sensor. After processing the information, according to a pre-set programme, control signals are generated to the pneumatic actuators.
The user communication system consists of the PLC keypad, a three-way switch, 6 buttons for manual control and the automatic display screen where one can see the activation of inputs (Fig. 7).
The keyboard allows the user to enter programs without a computer or modify certain parameters within an already created program.
The three-way switch is used to switch the mode of operation of the processing station. It allows switching from automatic mode to manual mode but also stops all pneumatic drive.
To avoid the dual simultaneous control, a separate PLC power supply switch was used which disconnects its power when the drive is operating in manual mode.
The 6 manual control buttons allow the control of the solenoid valves in the pneumatic drive.
An ejector type generator was used to create the vacuum: VN-07-H-T3-PQ2VQ2-RO1 [14].
Waircon URG 5/8 type regulators have been used to control actuator speed. The "URG" series flow regulators are produced in in-line, unidirectional versions [14].
The "URG" model [14] has a built-in control valve to control the flow in one direction, while the reverse flow is free. They are high precision regulators and can provide a high flow rate ratio and are very compact. For MK5100 IFM sensors were used to determine the position of pneumatic cylinders [14].
A Festo VASB-20 suction cup was used to hold the parts.

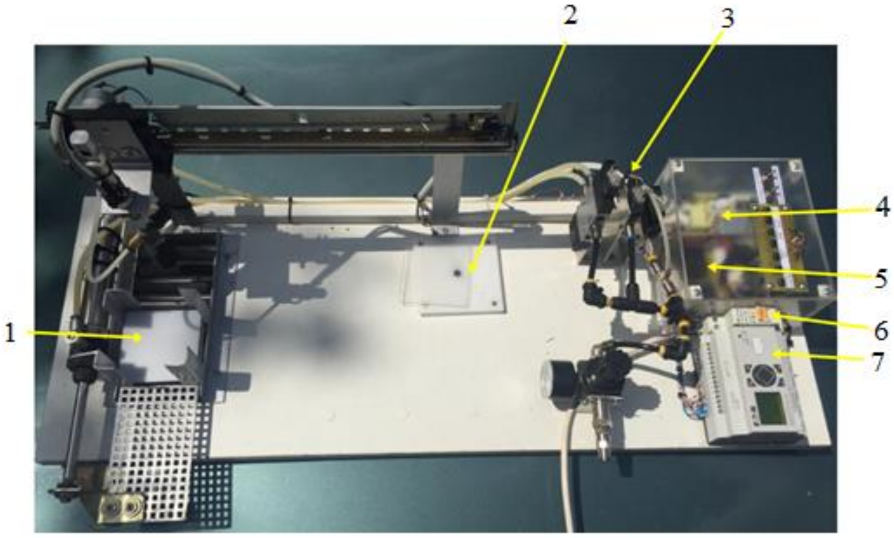

Fig. 7. Experimental model of the handling system made:
1- input piece stock; 2- output piece stock; 3- pneumatic valves; 4- DC power supply source; 5- relay module for adapting signals from sensors; 6- electrical protection 7- Eaton Easy 719 AC-RC PLC

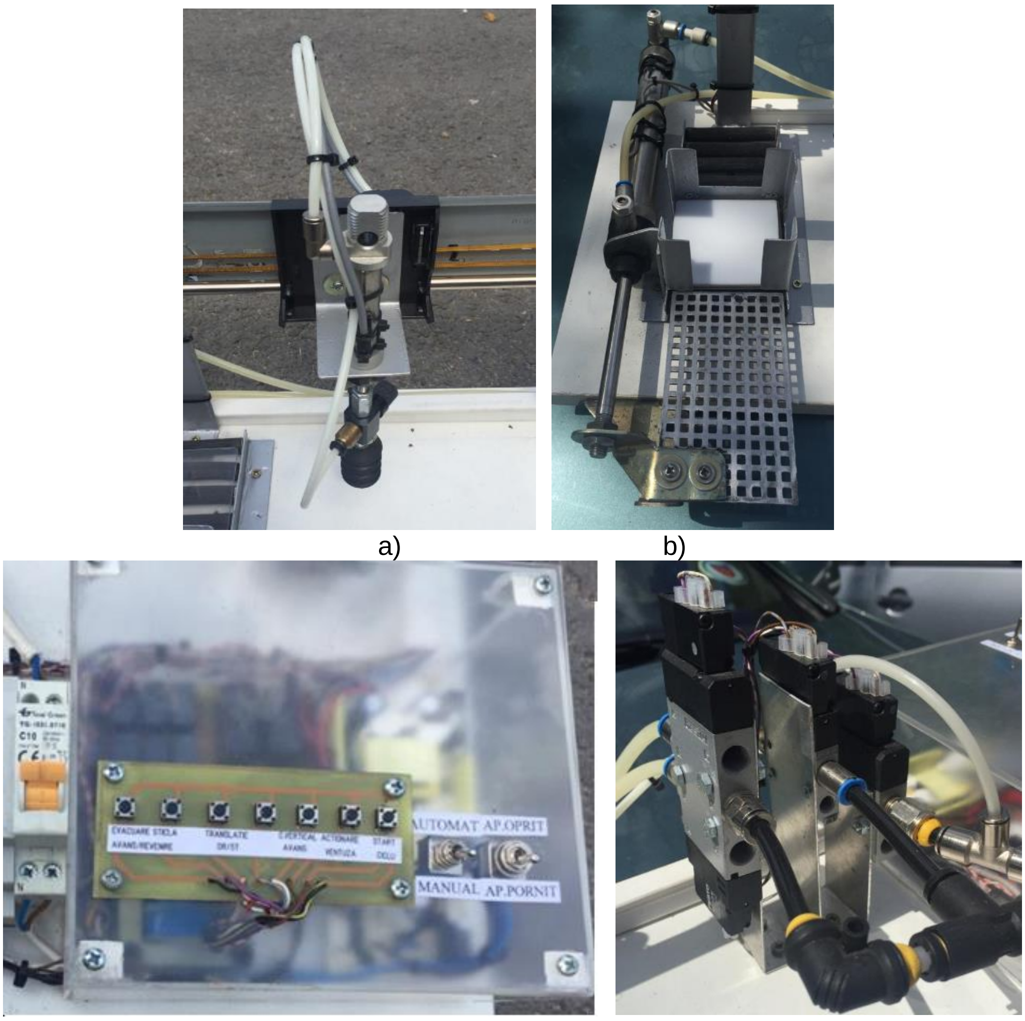

Fig. 8. Component modules of handling system: a) handling module; b) glass plate discharge module; c) manual control and protection module; d) pneumatic valves module

4.4. Development of the software for the Eaton Easy AC-RC-719 PLC

Starting from the simulated model, with the help of the PLC's own software, Easy-Soft, a program that respects the required operating protocol was made. EASY-SOFT is a PC program [15], with which one can create, store, simulate, document easily connection schemes that can be transferred later in an easy device ready for operation.
The verification of the software was done by simulation. The simulation of the program showed the correct operation according to the imposed protocol. After the simulation, the program was transferred to the PLC memory. The actual operation was then checked here as well. The correct operation was also verified in real conditions on the experimental system.

5. Conclusions

Industry in general and the machine construction, in particular, requires great flexibility of the manufacturing process, flexibility enabling the easy transition from the technical and cheap in terms of equipment and labour to another manufacturing. In this context, it is necessary to design and implement special equipment that will comprise flexible automation. Manipulators and robots, which ensure the construction features, functional characteristics and quality indicators for flexible manufacturing, have an important role in this equipment.
In this paper, a small-scale automatic system for handling glass pieces was designed and developed. It corresponds to the requirements and rigors imposed on a flexible manufacturing system.
Infrastructure hardware and software used allows monitoring and control of a handling system.
Both the pneumatic part of performed handling system and the electrical and command part were proven correct functioning according to the solution and protocol required.
The system designed, developed and tested can be used both in educational applications in electrical engineering and in industrial applications.

References

[1] *** https://www.buettelundmarx.de/.
[2] Drighiciu, M.A. *Hydro pneumatic drive and automation/Acţionări şi automatizări hidropneumatice*, Craiova, Publishing House of University of Craiova, 2003.
[3] ***. "About flexible production systems and complex automation." *Plant Engineering* 118, XIII Year, no. 11 (2013): 42-45.
[4] Hucknall, D.J. *Vacuum Technology and Applications*. Elsevier, 2013.
[5] Alboteanu, L., Gh. Manolea, and F. Ravigan. "Automatic sorting and handling station actuated by pneumatic drive." *Annals of the University of Craiova, Electrical Engineering Series,* no 1 (2018): 1-8.
[6] Alboteanu, L. "Automatic Processing Station Actuated by Pneumatic Drive." *Hidraulica Magazine*, no. 1 (March 2019): 16-22.
[7] Alboteanu, L. "Modeling an Automatic Processing Station Using Fluidsim Software." *Hidraulica Magazine*, no. 3 (September 2017): 27-30.
[8] ***. FESTO FluidSIM Pneumatic 4.2, Software. User manual.
[9] ****. https://www.eaton.com/us/en-us/catalog/machinery-controls/easy-programmable-relays.html.
[10] Alboteanu, I.L. "Pneumatic Tracking System for Photovoltaic Panel." *Hidraulica Magazine*, no. 1 (March 2015): 32-39.
[11] Avram, M., C. Bucşan, and V. Banu. "Innovative Systems for Incremental Positioning in Pneumatics." *Hidraulica Magazine*, no. 2 (June 2015): 52-56.
[12] Nawrocki, W. *Measurement Systems and Sensors.* London, Artech House Publishers, 2005.
[13] Toma, L. *Acquisition and digital signal processing systems / Sisteme de achizitie si prelucrare numerica a semnalelor*. Timişoara, "Vest" Publishing House, 1996.
[14] ***. http://www.festo.com/net/startpage/.
[15] ***. https://www.eaton.com/ca/en-gb/catalog/machinery-controls/easysoft.html.