# Automatic Processing Station Actuated by Pneumatic Drive

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***Abstract:*** *The paper presents an automatic processing system made on a small scale. The entire structure is integrated in an electro-pneumatic drive system with linear actuators and rotary pneumatic motors, supplied by the solenoid valves. The system is controlled by a PLC in accordance with the required operating protocol.*

***Keywords:*** *Automatic, PLC, pneumatic, processing station.*

## 1. Introduction

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 [1].
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" [2].
Robots and manipulators are the most complex and flexible machines that have been created and used by man so far that incorporate pneumatic drives. Taking into account these considerations the paper presents an automatic processing system using a manipulator robot and a pneumatic actuation system purpose in [3].

## 2. Structure of processing station

The processing station consists of a machine tool (MT) with a stock of raw input pieces and a stock of output semi-finished products (Fig.1) and a manipulator robot (MR) transferring the work pieces from the stock Input to the machine tool [3].

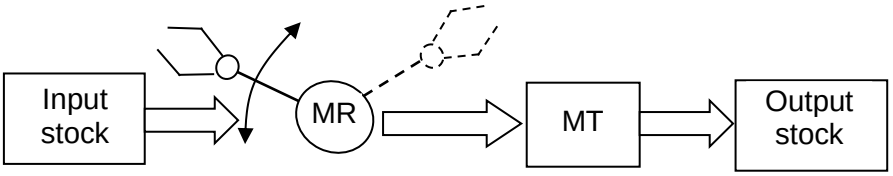


**Fig. 1.** Structure of processing station

It is considered that the MT performs a single operation (for example, pressing, stamping, drilling, threading, etc.) on a single ingots. It is also considered that both input and output stocks have a limited capacity at a semi-finished product.
The entire structure is integrated in an electro-pneumatic drive system with linear actuators (pneumatic cylinder) and rotary (rotary pneumatic motors), controlled by monostable and bistable valves [4].
Thus, the manipulator robot- MR comprises four modules and machine tool- MT comprises a main processing module and the outlet module machined semi-finished products (Fig. 2).
A complete working cycle of pneumatic drive involves following sequences:

1. Advance C4→ Advance C1→Retraction C4→ Retraction C1;
2. Advance C3→ Left rotation MP2→ Advance C1→ Advance C4;
3. Retraction C1→ Retraction C4→Right rotation MP2→ Retraction C3;
4. Advance C5→ Retraction C5→ Advance C6→ Retraction C6

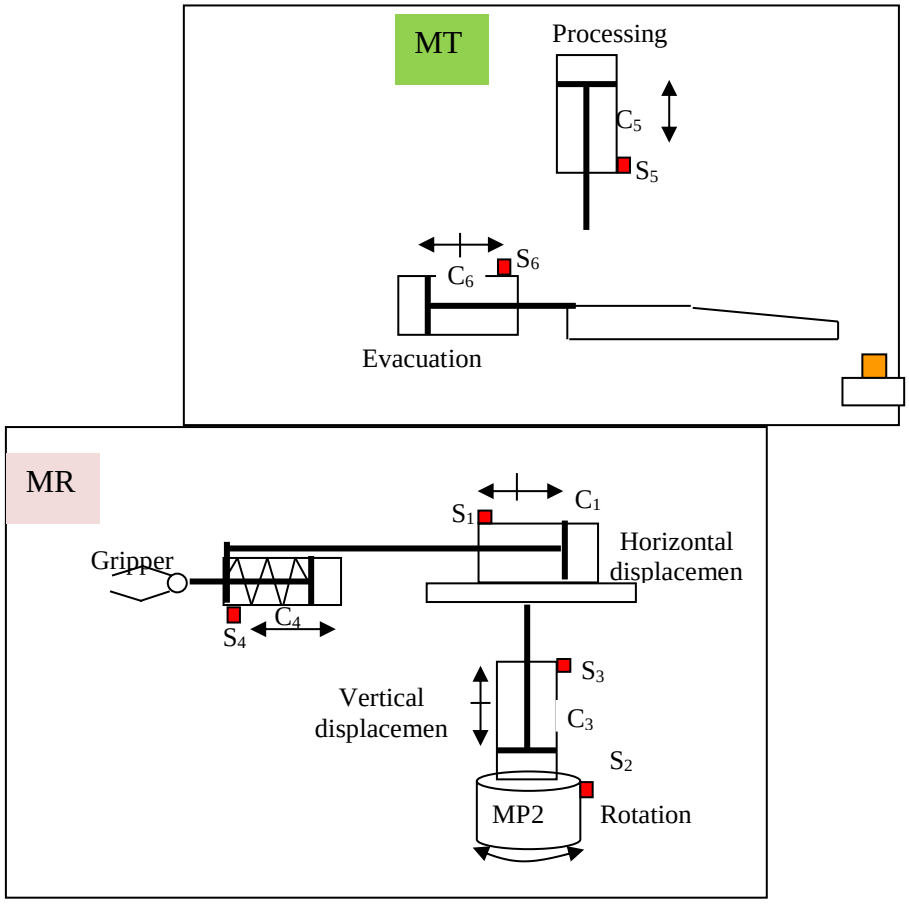


**Fig. 2.** Structure of pneumatic drive of the processing station

Based on the structure of the pneumatic drive was carried general scheme of the automatic processing station (Figure 3).

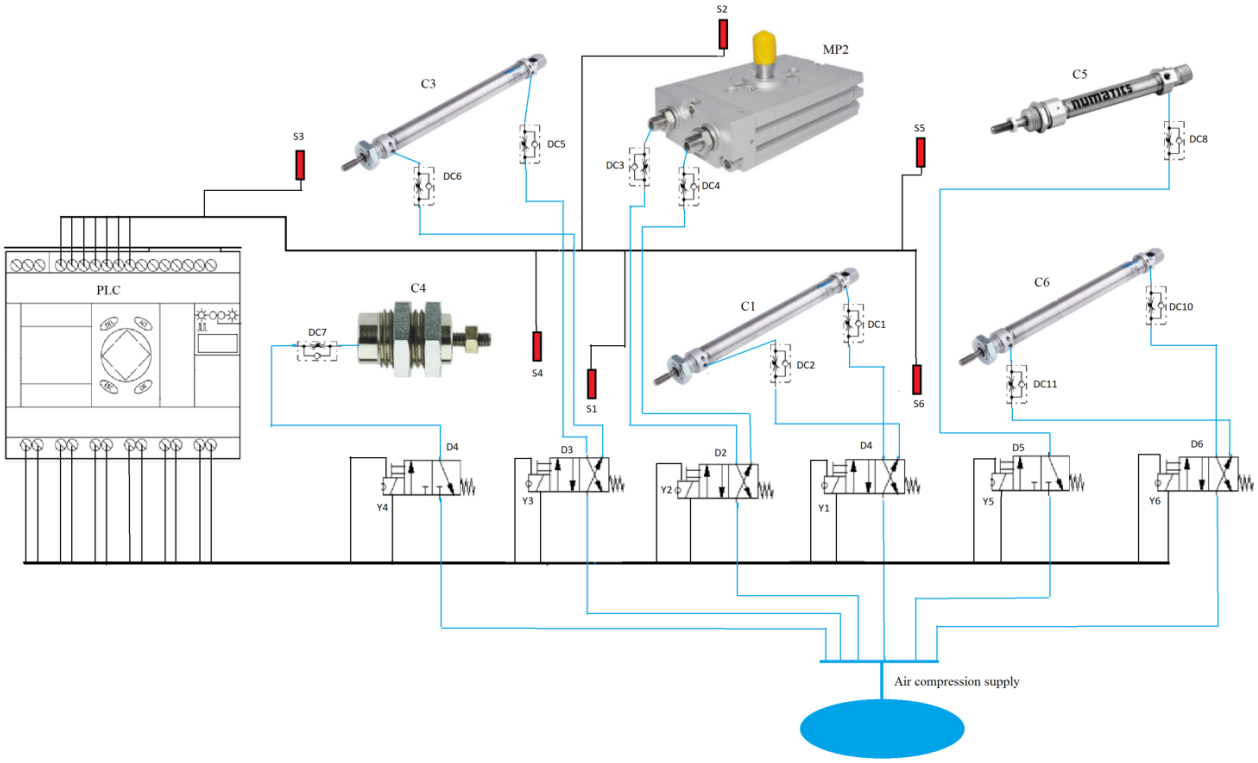


**Fig. 3.** General scheme of automatic processing station

The meaning of the elements used in the scheme is as follows:
PLC- programmable logic controller;
D1...D6 – pneumatic valve;
C1...C6 – pneumatic cylinders;
MP2 – rotary pneumatic motor;
DC1...DC11 – one-way flow control valve;
S1...S6 – sensors;
Y1...Y6 – relays valve control.

## 3. Achievement the automatic processing station

### 3.1. 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 Moeller Easy AC-RC-819 programmable controller was selected.
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.

### 3.2. Achievement the power and protection circuit

For application operation, it is necessary to 220V power supply of the PLC as well as a 24V source so that the coils of the 6 valves and the sensors used operate at a voltage of 24V. Figure 4 shows the electrical circuit diagram of the processing station.

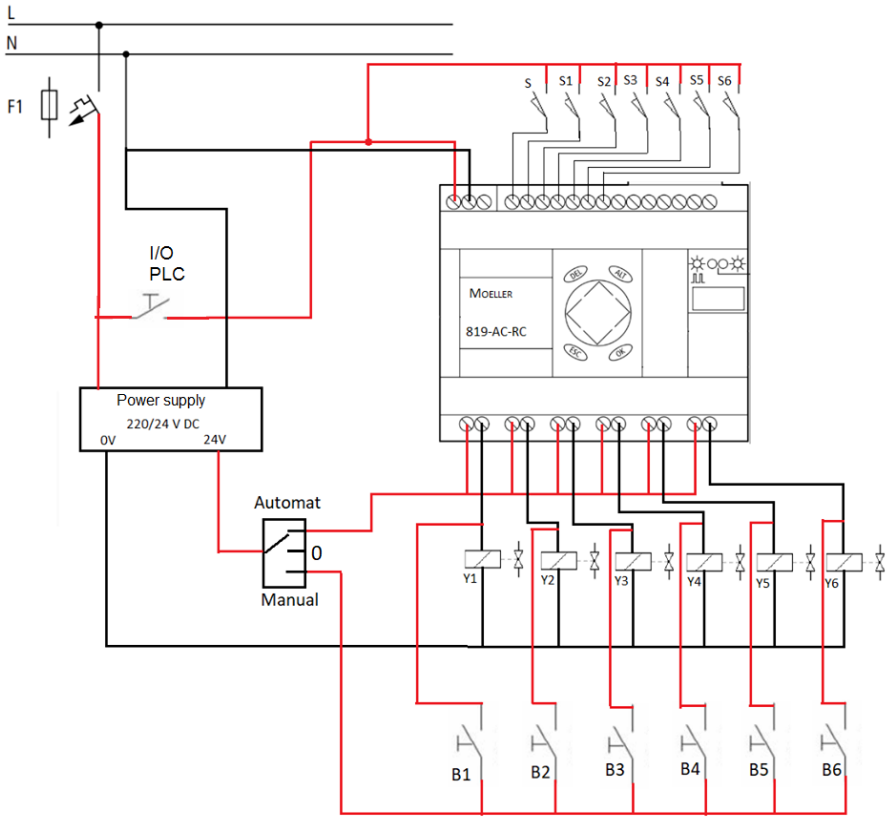


**Fig. 4.** Electrical circuit diagram of the processing station

### 3.3. Achievement the user communication system

At the core of the control process lays the command and control unit that manages the entire process as well as the human-machine interface.
Based on the operating principle of a closed-loop control system, 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, after a predetermined schedule, 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 you can see the activation of inputs (figures 4 and 5).
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.

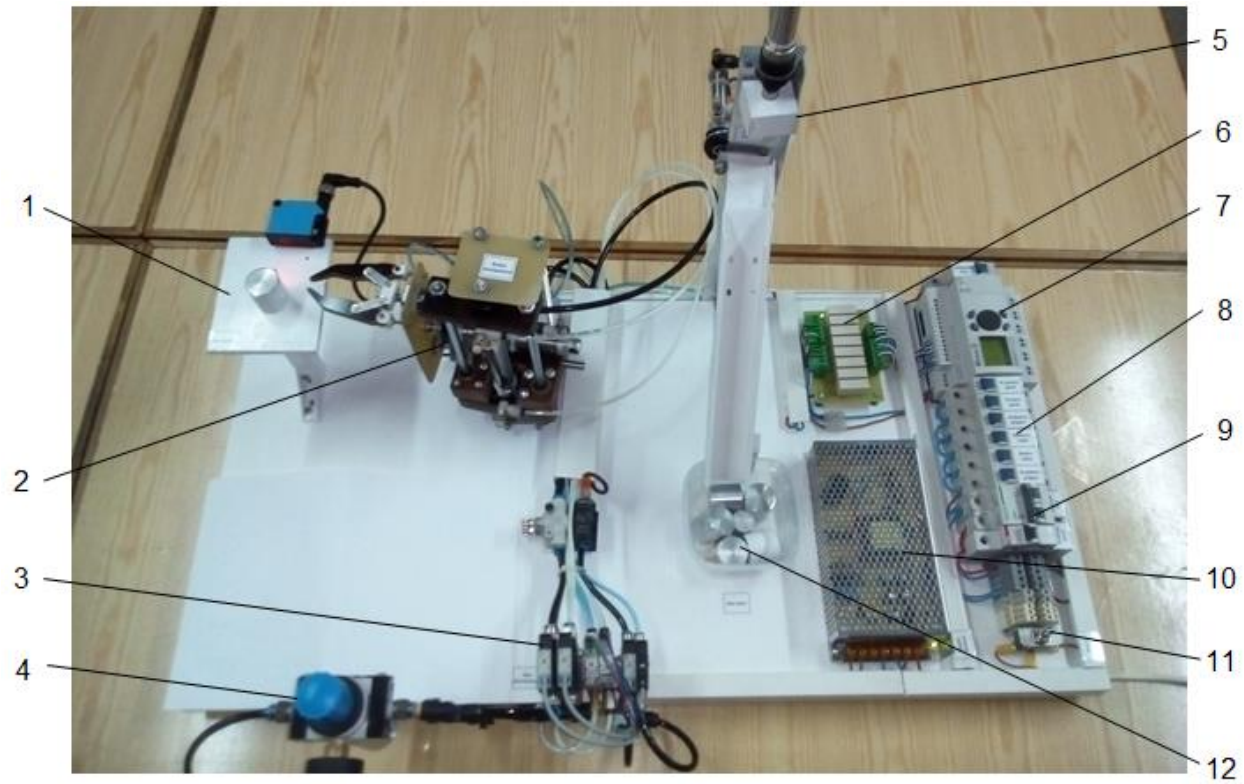


**Fig. 5.** Accomplished processing station:
1- input piece stock; 2- manipulator robot; 3- pneumatic valves; 4- air preparation group; 5- machine tool; 6- relay module for adapting signals from sensors; 7- Easy 819 AC-RC PLC; 8- switch for manual control mode; 9- electrical protection; 10- DC power supply; 11- three-way switch for operation mode selection; 12- output piece stock.

The air preparation group is FR type produced by SMC. This combination minimizes space and pipelines by integrating the two units into one. Standard features include a regulator that can be quickly locked by pushing the adjustment knob down. A pressure gauge is mounted on the control group. The filter cartridge provides a filtration rate of up to 5 microns/m.
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.

The "URG" model 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.
Closed open positions of the gripper are given by a pressure relay type: Festo SDE5-D10-O-Q6-P-M8 inserted into the pneumatic actuator of the gripper.
SICK K3L-P3216 type sensor was used to detect the presence of the piece to input stock.

## 4. Experimental results

Experimentation actually consists of correct working verification according to the protocol and conditions imposed by design. In figures 6 a)…6 f) there are captured the 6 operating states in a work cycle.

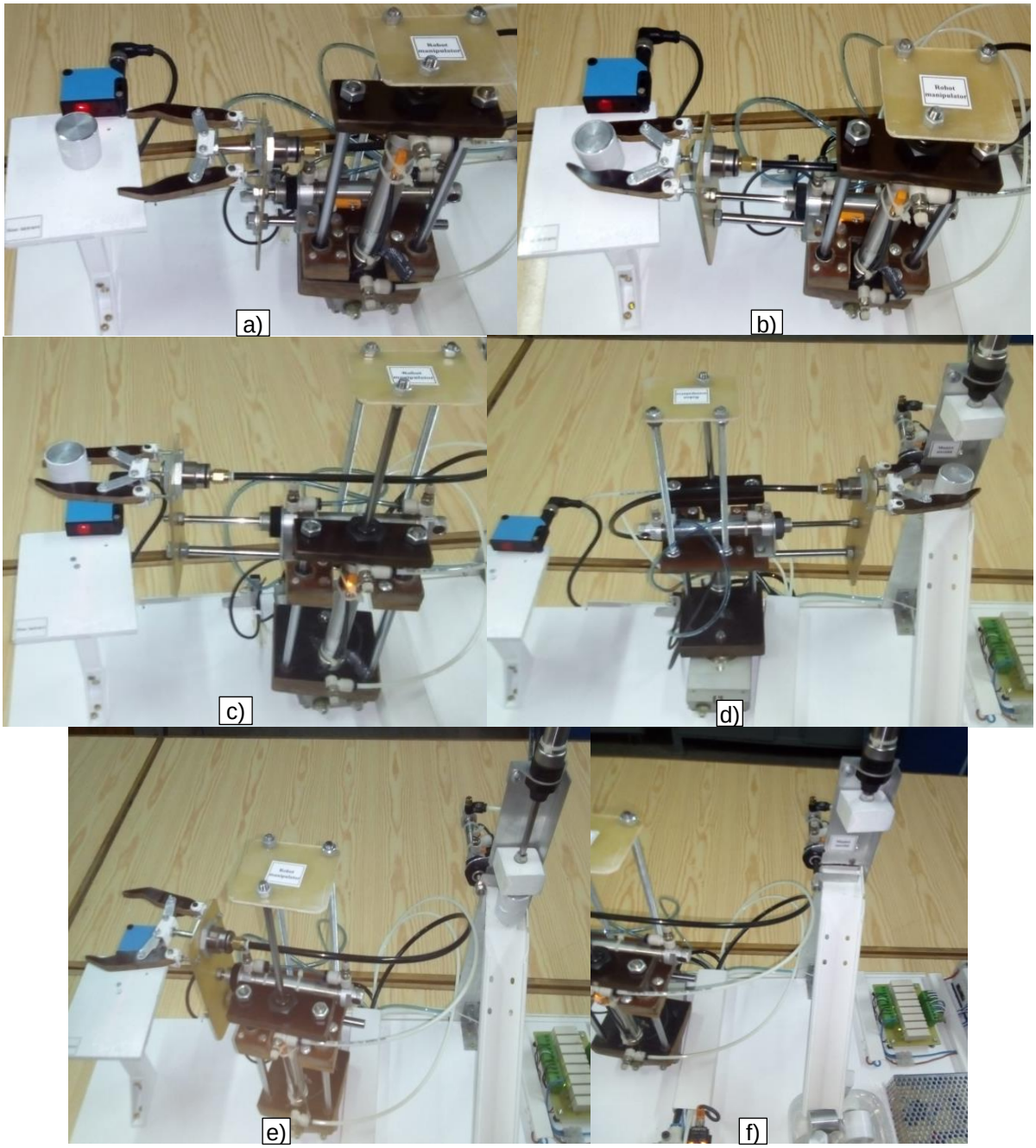


**Fig. 6.** Working states of processing station: a) piece detection; b) piece grip; c) lifting the piece; d) putting the piece on the tool machine; e) processing the piece; f) piece evacuation.

Other experiments consisted of visualizing command signals generated by the PLC for supplying valves to actuators. Figure 7 shows the diagrams of the two working cycles.

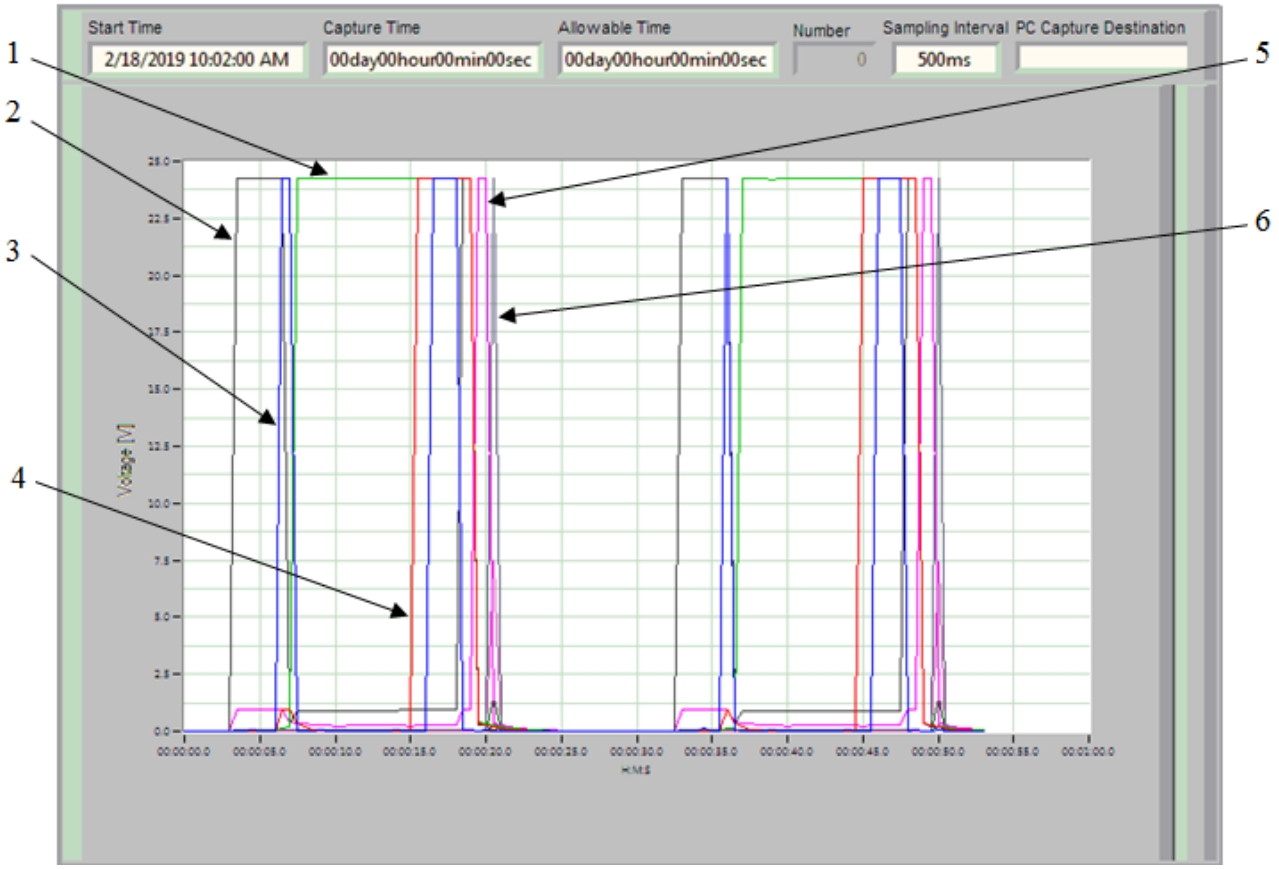


**Fig. 7.** Recording of command signal diagrams generated by PLC: 1- lifting arm of robot; 2- opening gripper; 3- robot arm pushing; 4- robot rotation; 5- piece processing; 6- piece evacuation.

Based on the diagrams, an optimization of the automatic processing system can be done. For example, working times can be reduced.

## 5. Conclusions

In the paper was designed and developed an automated processing station that respond to the requirements of a flexible manufacturing system.
Infrastructure hardware and software used allows monitoring and control of a processing station.
Sensors, electrical equipment and electronic components used for automatic system design have a high degree of accessibility and performance. Both the pneumatic part of performed processing station as well as electrical and command part was 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.

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