

Development and computer based simulation of pneumatic conveying control system

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Abstract. The paper presents a review of the core components of the container delivery system in technological products, covering the control signals necessary for the operation of the pneumatic transport system. The functional scheme of the pneumatic container delivery system has been developed, and the number of control signals has been optimized. A schematic diagram of the pneumatic transport control system was developed and a computer based simulation was performed.

1. Introduction

The modern robotic cell widely features the devices that perform the same type of technological operations in the course of performing process [1,2]. Such devices include systems of pneumatic container delivery of goods via transmission pipelines. Container delivery systems are used in automated systems of analytical control of various technological processes at mining, processing and metallurgical enterprises for the delivery of representative samples of technological products for express analysis.

The structure of such systems includes the following core components [3-5]:

- devices for automatic transport container loading;
- the system of transmission pipelines;
- devices for automatic transport container unloading;
- automatic turnouts of the containers movement direction.

2. The functional diagram of the transport system

The functional diagram of the transport system intended for the delivery of technological samples is shown in Fig.1. The following symbols are defined in the figure.: SLS1, SLS2 - samples load station; TS1, TS2 – turnout section (TS); SUS – samples unload station, DAPL1, DAPL2 - devices for automatic preparation and loading of a single sample; DSS – device for collecting single samples.

Each block of the diagram has a built-in control system (CS). The CS units are activated by the commands from the central control system (CCS), which allows implementing a programmed transport container route.

Samples of the technological product are prepared by DAPL, loaded into transport containers at sample loading stations (SLS1, SLS2) and transmission pipelines (marked with double arrows in the diagram), through the turnout (TS), to samples unload station (SUS) where the unloading delivered samples from transport containers to the marked trays of DSS is done.



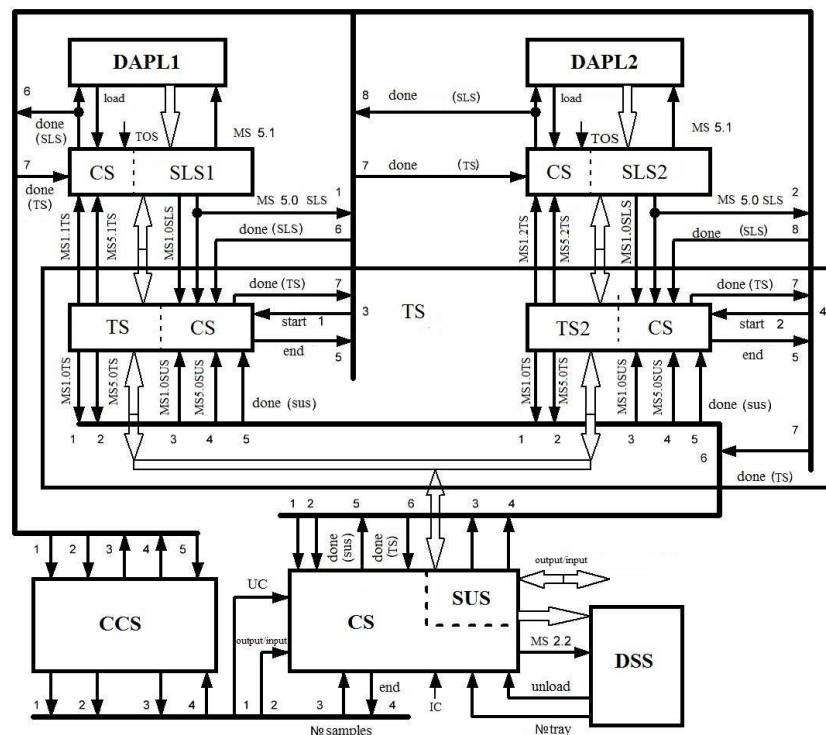


Figure 1. A functional diagram of the container delivery system

Figure 1 shows the control signals that ensure the interaction of system devices in the automatic mode. "MS" signals are generated by magnetic sensors having the same name, which are part of the system.

DAPL devices generate a "load" signal, which is fed to the appropriate SLS and informs it on the readiness to load a single sample. The MS5.1 signal informs the DAPL about the readiness of the SLS to accept the sample.

Turnout sections (TS1, TP2) interact with the corresponding stations SLS1, SLS2 by means of the signals MS1.i, MS5.i, where I (section number) takes values from 1 to 2. The signals MS1.iTS and MS5.iTS are generated by section sensors turnout. Signals MS1.0SLS and MS5.0SLS come to the TS from the corresponding stations of the SLS.

To turn off the SLS stations, the signal "TOS" (turn off the station) from the operator panel is used.

Signals MS5.0SLS, generated by sensors of SLS stations, also come via the information bus (wire lines with numbers 1, 2 are used) to the central control system of the CCS and allow identifying the number of a single sample, in the form of a signal, "Sample No." of SUS station.

To control the turnout sections, the CCS generates the signals "start" (wires: 3,4 information bus), which include the power supply of the corresponding control system, which, in accordance with the operation algorithm of the control system, serves SLS stations ready for sending the turnout container. The CS of each TS section generates an "end" signal (wire number 5) informing the CCS of the end of the operation of this turnout section.

Turnout sections exchange information signals: MS1.0TS, MS5.0TS (formed by TS sections) and MS1.0SUS, MS5.0SUS (formed by the SUS) with the SUS station.

The SUS station can operate in two modes: "unload the container" (the operation mode is set by the CCS using the signal "UC") and "input / output of the container" (the mode is set by the signal "Output / IC"). If it is necessary to remove any transport container for the prevention or for replacement, the operator enters a CS command to transfer the operation of the installation to the mode of "output /

input of a transport container", an "Output/ IC" signal is generated. The CS performs the necessary switching in the SLS operation mode, and the container is output through the container Input / Output node (Fig. 1). The operator enters, if necessary, a "new" transport container into the installation and generates a "IC" signal (input container) using the control panel. The CS control system transfers SUS to the automatic control mode in accordance with the specified algorithm.

To coordinate the SUS operation and DSS signals, the following are used: MS2.2, "unload" and "tray number". The unloading of the sample begins after the MS2.2 signal is received in the DSS and occurs only when the receiving tray number (signal "Tray No.") coincides with the number of the delivered sample (signal "Sample No."). After the unloading of a single sample is completed, the DSS generates an "unload" signal.

3. The functional diagram of the turnout

Fig. 2 shows the functional diagram of the turnout.

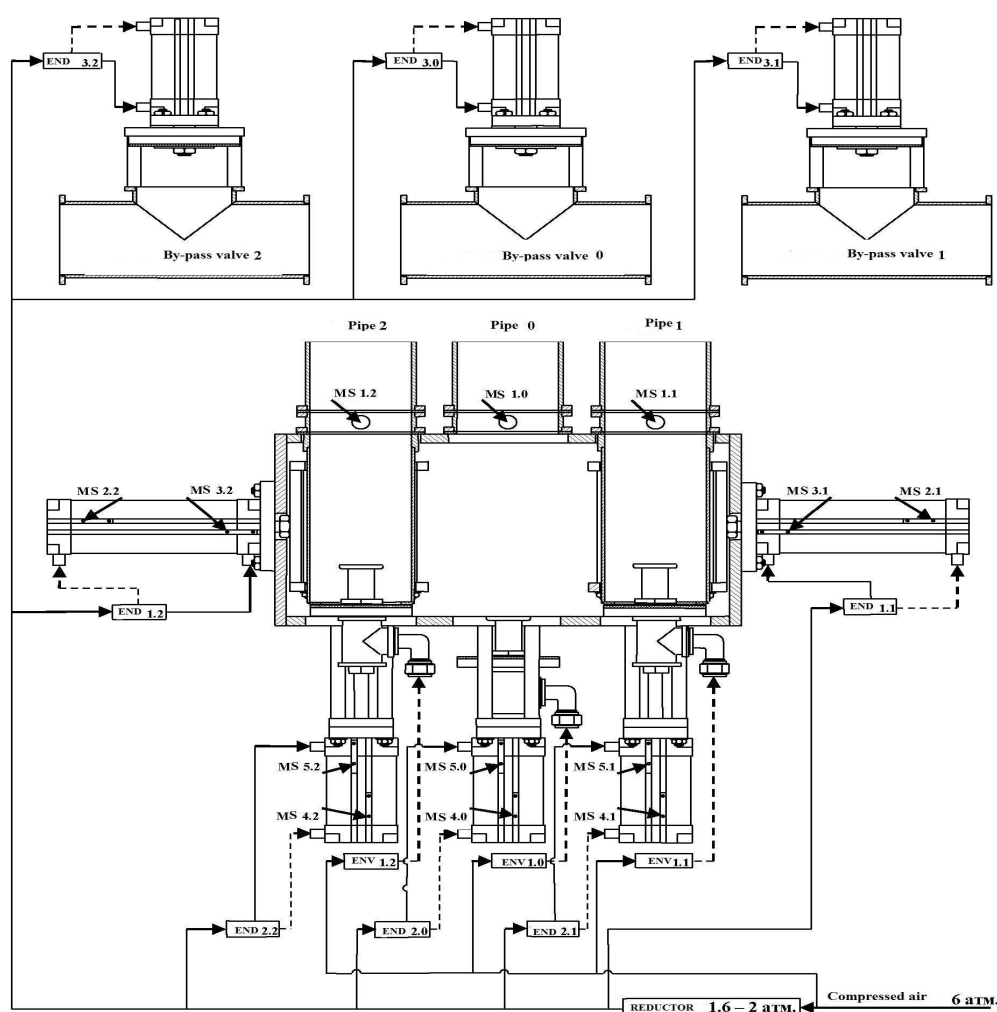


Figure 2. Scheme of turnout

The following abbreviations are used:

- MS1.i - magnetic sensors that generate information signals when a transport container arrives (i - sensor number);

-MS2.i - MS5.i - magnetic sensors for positioning the pistons of horizontal and vertical pneumatic cylinders that form information signals when the pistons of the pneumatic cylinders move to the extreme positions;

-END1.i, END2.i and END3.i - electro pneumatic distributors of compressed air supply, controlling the operation of pneumatic cylinders;

-ENV1.i - electro pneumatic valves controlling the supply of transporting compressed air to send the container through a transmission pipeline.

Loading and unloading stations for technological products (Fig.1) are structured in a similar way and contain the sensors, depositors and valves noted above.

By-pass valves (BPVi) are installed in the immediate vicinity of each device of the transport system to "vent" the air pressure in the transmission pipelines.

All devices with a control system (CS), movable carriages are moved with the receiving container of the transport container, which allows receiving, sending and transferring the container from one pipeline to another. When these nodes are moved by means of magnetic sensors (MSi) fixing the extreme positions of the piston of the pneumatic cylinder, information signals are generated which are used by the logic device CS to generate control commands to switch on or off the corresponding electro-pneumatic valve (ENVi) or the electro pneumatic distributor (END i).

4. Development of the schematic diagram of a universal control system

To implement these functions, a schematic diagram of a universal control system (Fig. 3) designed to control the devices of a container delivery system for the samples, as well as to perform the functions of a central control system (CCS), was developed. The choice of the structure of the diagram is due to the need to receive and generate a large number of signals.

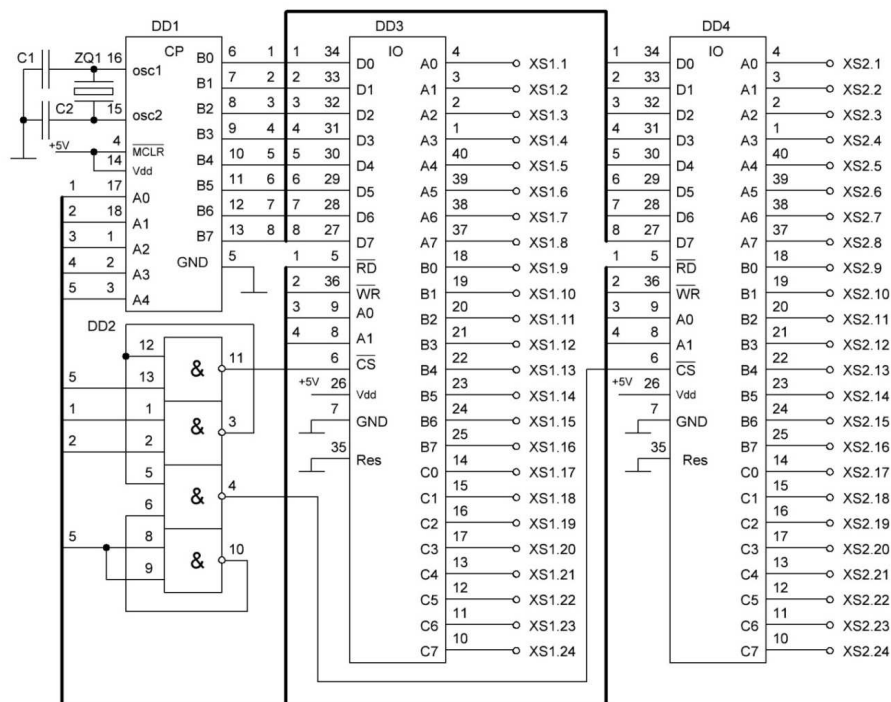


Figure 3. A schematic diagram of the control system

The diagram consists of the following elements: DD1-microcontroller (PIC16F84A); DD2-the logical elements of the AND-NO (K561LA7); DD3, DD4 - devices of input / output (KP580BB55A). Based on DD2, a decoder designed for selecting devices DD3, DD4 is executed.

The information necessary for the operation of the system comes through contact pads XS1.1-XS1.24. This information consists of the signals generated by the magnetic sensors (MSi), and also includes the signals coming in and out to the adjacent devices of the container sample delivery system in accordance with Fig. 1.

The contact pads XS2.1-XS2.24 connect the electro pneumatic distributor (END i) and the valves (ENV i.) controlling the operation modes of the devices (SLS, TS, SUS) of the system. These contacts also display the information about possible abnormal situations occurring in the monitored device.

To develop and debug the software that provides for the functioning of the transport system, a computer model of the considered control system is developed using PROTEUS software (Fig. 4).

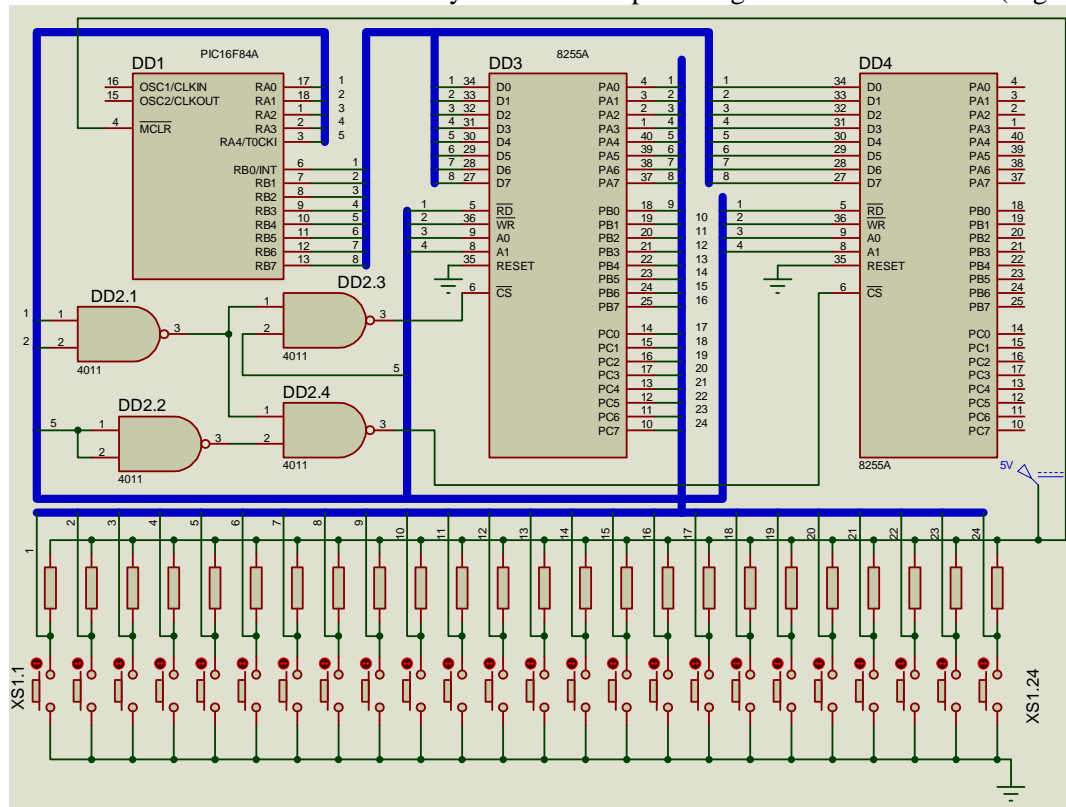


Figure 4. A computer model of the control system

Buttons XS1.1-XS1.24 set the combinations of input signals corresponding to the operating modes of the stations in the transport system, and by registering the signal levels at the outputs of the DD4 chip, it is possible to control the signals transmission from the actuating devices (pneumatic valves and pneumatic distributors).

5. Conclusion

The results of the research can be used in the construction of pneumatic transport systems at mining, processing and metallurgical enterprises.

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