Automatic diagnostics of switches of pneumatic transportation system

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Abstract. The article dwells on the up-to-date issues of the automatic microprocessor-based diagnostics of the automatic switches, which are a part of the pneumatic sample capsule transportation for an assay with the maximum use of the automatic control devices. A structural diagram of the pneumatic transport system has been developed. The article deals with the functioning of the main components of the pneumatic transport system. An algorithm for the functioning of the microprocessor control system in the diagnostic mode is developed and the structural diagram of the algorithm is shown. A scheme of a microprocessor control system for the components of a pneumatic transport system has been developed.

1. Introduction

The automatic switches are used in the pneumatic transportation system of the pneumatic representative sample capsule transportation for an assay and ensure optimal routing of the pneumatic capsule delivery for an assay of controlled engineering products [1]. Systems for pneumatic sample capsule transportation for an assay are a part of automated analytical control of products manufactured at ore dressing and metallurgical plants [2].

The available systems of pneumatic cargo transportation via transportation pipelines vary greatly with regard to the design and various areas of application [3-10].

2. Main section

The system for automatic pneumatic representative sample capsule transportation for an assay consists of the following main units [1, 2]:
- Stations for automatic charging (SCS) of an averaged sample into a capsule and conveyance of the capsule with the sample to a quick assay laboratory;
- Stations for automatic discharging (SDS) of the process samples from the capsule and automatic return of an empty capsule to a sampling point;
- A transport piping system between the sampling points and the analytical laboratories making assays;
- Automatic switches (SW) that are used to change the direction of moving loaded capsules automatically from the automatic charging stations of an averaged sample to the central pipeline, which is connected to the automatic discharge station of the process samples delivered for an assay from the capsule and return of empty containers after their unloading.

The structure of stations (SCS, SDS) and automatic switches (SW) includes control systems (MCS). Information signals are transmitted between control systems. The operation of the pneumatic
conveying system is controlled by the central control system [2]. The central control system (CMCS) controls the direction of movement of the container. The CMCS generates the signal "Start", which is sent to the devices of the pneumatic transport system, which must work at this time. The devices of the pneumatic transport system, having completed the work, send an information signal "End" to the CMCS.

The design and operating principle of the automatic sample charge station in the capsule is described in [11] and [2].

The operating principle for the switch is described in the monograph [1] and depicted in Figure 1.

Figure 1 contains the following symbols: MP1.0, MP1.1 and MP 1.2 are magnetic pick-up responsible for formation of data commands on a capsule arrival into SW via transportation pipelines; MP 2.1, MP 2.2, MP 3.1, MP 3.2, MP 4.0, MP 5.0, MP 4.1, MP 4.2, MP 5.1 and MP 5.2 are magnetic pick-ups of SW piston, positioning air cylinders responsible for the formation of data commands; when the pistons in the air, cylinders move to the end positions; EPD 1.1, EPD 1.2, EPD 2.0, EPD 2.1, EPD 2.2, EPD 3.0, EPD 3.1 and EPD 3.2 – electro pneumatic compressed air distributors which govern the air cylinders; EBV 1.0, EBV 1.1 and EBV 1.2 – electro pneumatic bypass valves which govern compressed air supply for capsule conveyance from SW via the transportation pipeline; BV 1.i – bypass valves that ensure necessary conditions for acceptance and dispatch of the capsules.

In the initial condition of the automatic switches, the receiving sockets 1.1 and 1.2 of the gauge carriage 2.1 and 2.2 are under peripheral transportation pipelines in the position that ensures acceptance of the delivered capsule. The power is not supplied to any microprocessor-based control systems (MCS), electro-pneumatic distributors and electro pneumatic valves; the compressed air is supplied to the relevant air cylinders through normally open outlets of all EPD. The initial condition of SW is characterized by the simultaneous sending of information signals from MP 2i, MP 4.0 and MP 5i in MCS.

The operating experience of the effective automatic pneumatic system of the capsule transportation for an assay allowed for developing and implementing the automatic microprocessor-based system for diagnostics of SW performance, which algorithm can be seen in Figure 2.

The program that runs this algorithm is introduced into the universal standard systems of microprocessor control [2] and uses information about the condition of own magnetic pick-ups (MP) of the piston location of the air cylinders.

The developed algorithm of the automatic technical diagnostics of the performance of the automatic switch can be implemented every time the pneumatic transportation system is turned on or at any time of its operation based on the request from the operator servicing this system.

The results of technical diagnostics of automatic SW performance (lack of necessary information signals from the magnetic pick-ups) can be seen on the relevant display boards, which allow the maintenance staff to identify a malfunctioning unit quickly. In the absence of malfunctions, the display board shows a relevant message (ready SW), and the control system automatically proceeds to implementing the basic algorithm of the pneumatic transportation system operation.

The basic mode of operation is shown in Figure 3.

The circuit diagram of the microprocessor-based control system and automatic technical diagnostics (MCS) of the automatic switches (SW) of the pneumatic transport system, which can be seen in Figure 4, have been designed considering the foregoing.
Figure 1. Automatic switch initial condition.
Figure 2. Algorithm for technical diagnostics of SW.

Figure 3. Algorithm of basic mode of operating.
Figure 4. Circuit diagram of microprocessor-based control system and automatic technical diagnostics.
The circuit diagram is based on the microchips, namely: DD1–microcontroller (PIC16F84A); DD2–logical elements I-NE (CD4011A); DD3, DD4–I/O devices (NTE8255).

The circuit diagram has hardware redundancy to enable connection of additional sensors and devices, and thus expand functional capabilities of the capsule sample delivery system.

The information needed for operation of the control system comes via contacts of the XS1 connector. The information comprises commands generated by magnetic pick-ups (MPi).

Contacts of the connector XS2 are intended for connection of electro pneumatic distributors (EPDi) and valves (EPVi). The information signals shown in the figures provide interaction between the devices of the transport system. The information signal "Ready" is generated by the devices when they are ready for operation.

Information about potential abnormal conditions in the controlled devices is the output on the contacts of the connector XS3. This information is controlled by MCS and when the basic mode algorithm is executed.

3. Conclusion

The designs, schematics and algorithms developed and discussed in this article are universal and can simplify the processes of the pneumatic transportation equipment set-up and maintenance. They can be widely used to design sample pneumatic delivery systems for further analysis, aimed at optimizing the processes at mining, ore dressing and metallurgical plants.

References

[1] Khmara V 2012 All-purpose microprocessor-based capsule system of pneumatic transportation of samples for assays Saarbrücken Germany Lambert Academic Publishing p 96

[2] Lobotsky Y G, Khmara V V, Kabyshev A M and Dedegkaev A G 2015 Modern Applied Sci. 9(5) 228–246

[3] Liu H 2007 Japanese Journal of Multiphase Flow 21(1) 57–69

[4] Sandor T, Endre M and Szilard K 2012 Int. Sci. Conf. on Sustainable Development & Ecological Footprint March 26-27 Sopron Hungary, pp 1–4

[5] Bosikov I 2015 Prob. of the Human. and Sci. 3(1) 48-52

[6] Futamura M 2005 Powder Handling and Processing 17(1) 12–17

[7] Pielage B A 2001 Proceedings of the IEEE Intelligent Trans. Systems Oakland pp 762–767

[8] Lai Yeng Lee, Tai Yong Quek, Rensheng Deng, Madhumita B Ray and Chi Hwa Wang 2004 Chemical Eng. Sci. 59 4637–51

[9] Hodson N 2008 Proceedings from the Int. Symp. on Underground Freight Transportation by Capsule Pipelines and Other Tube/Tunnel Systems ISUFT Arlington Texas March, pp 20–22

[10] Mills D, Agarwal V K 2001 Pneumatic conveying systems (Trans tech publications) p 345

[11] Lobockij YU G, Hmara V V 2014 Ustoichivoe razvitie gornyh territorij 2 30-36