Modernization of the automation control system of technological processes at the preparation plant in the conditions of technical re-equipment

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Abstract. The experience of modernization of the automation control system of technological processes at the preparation plant under the conditions of technical re-equipment of the preparation plant “Barzasskoye Tovarischestvo” LLC (Berezovsky) is considered. The automated process control systems (APCS), the modernization goals and the ways to achieve them are indicated, the main subsystems of the integrated APCS are presented, the enlarged functional and technical structure of the upgraded system is given. The procedure for commissioning an upgraded system is described.

1. Introduction
Coal mining is inseparably linked with its processing – enrichment, therefore, together with mines and coal open-pit mines the preparation plants have been long functioning [1-3]. In addition, modern market realities are such, that in the presence of constant demand it is necessary to increase the production capacity of the enterprise. Thus, a modern mining enterprise is a “living” organism, constantly changing its technological and logical structure and, accordingly, automation systems of technological processes. At the preparation plant “Barzasskoye Tovarischestvo” LLC (Berezovsky) the decision has been made to carry out technical re-equipment with increasing the production capacity and qualitative indices of coal enrichment mined at the open-pit mine “Barzassky”. At present, the modernization of the technological complex is connected with the modernization of automation systems of the corresponding technological processes.

2. Brief characteristics of the control object
Within the framework of technical re-equipment it is planned to create two sections: a flotation-filtration and drying-furnace ones, and the modernization of the existing technological complex of the concentrate storage. The operating preparation plant is a complex facility with a lot of technological equipment, continuous transport lines with their territorial distribution. Moreover, technological processes are automated, and the task of modernization is, inter alia, in the targeted change of the
existing automation system that allows, with minimal material and time costs, the automation of newly introduced equipment and technological processes to be implement without disrupting the overall system.

The automated process control systems (APCS) implemented within the framework of modernization is intended for complex automation of control and management of production and technological processes, equipment of a re-equipped preparation plant [4-7], including the solution of the following additional tasks (taking into account that the existing system fully performs the functions assigned to it and does not require the modernization of any software): centralized control, analysis and display of information on the state of production and technological processes and technological complex equipment of the flotation-filtration and drying furnace sections, a concentrate storage; automation control of technological processes and equipment of the technological complex of flotation-filtration and drying-furnace sections, a concentrate storage.

3. The purpose of system creation
The purpose of modernization is to increase the efficiency of technological complex control of the flotation-filtration section; drying-furnace section; concentrate storage and, as a result, improvement of technical and economic indicators of its functioning: decrease in unit costs for production and increase in the production of a good product; as well as improvement in the quality of commercial products.

The achievement of this goal is provided in the following directions:
1. Automation of information and control functions in solving problems: operative formation and analysis of information on changes in operation modes and the state of technological processes, units and equipment; operative consistent correction of tasks for the operating conditions of technological processes; operative implementation of control decisions and regulation of technological parameters; control, accounting and analysis of violations of technological and production discipline, management effectiveness.

2. Improvement in the reliability of automation system for technological complex control, efficiency and quality of control and management due to: application of modern technical means, methods and algorithms for automatic control, analysis, diagnostics of the state and control of technological processes and equipment; complex and detailed display of information on the state of equipment and units, changes in technological parameters, actions of operational personnel in the system; use as a technical base on the lower level of a system of modern microprocessor controllers with high reliability, long time between failures, easy replacement of failed components, expansion of technical structure, modification of mathware and software; minimization of the number of unreliable electromechanical devices in local systems of logical control and control of individual mechanisms and units.

4. Functional structure of the system
The automated process control system for the flotation-filtration, drying-furnace sections and concentrate storage (APCS FFS) is developed as a component of the integrated automated process control system for the preparation plant (APCS PP) of the preparation plant “Barzasskoye Tovarischestvo” LLC, based on the existing software-hardware means of the operating APCS PP of the technological complex of enrichment of the I and II stages and the loading complex. The APCS FFS is developed taking into account the maximum possible use of the resources of already existing technical means of the automated process control system, unification of software and hardware for the designed APCS FFS and the operating APCS PP of the technological complex of enrichment of the I and II stages.

The integrated functional structure of the integrated APCS PP is shown in figure 1.
Figure 1. Diagram of the functional structure of the integrated APCS PP of “Barzasskoye Tovarischestvo” LLC.

It consists of the following main systems:

1) the existing APCS PP of the first and second stages, including:
   - automated system for the centralized collection, processing and storage of information on PP;
   - engineering support system;
   - automated control system of production (ACSP);
   - automated system of real-time operations control (ASROC) of PP technological complex;
   - local centralized control and loading control system;
   - automated control systems and technological complexes control (AS TC) for coal intake, enrichment and loading of the I and II stages;

2) the projected APCS FFS, including:
   - automated system for the centralized collection, processing and storage of information on the flotation-filtration and drying-furnace sections;
   - automated system of real-time operations control of the technological complex of the flotation-filtration and drying-furnace sections (ASROC FFS);
   - system of automated control and loading control in the part of newly installed equipment at the concentrate storage;
   - automated control systems and technological complexes control of the flotation-filtration section (ACS TC FFS);
   - automated control systems and technological complexes control of the drying-furnace section, supplied with the technological equipment, including the local system of centralized control and control of drying units (ACS TC CTO).
Integration of the existing APCS PP of the first and second stage and the newly created APCS PP FFS and the creation of a complete automated PP technological complex is provided by:

- creation of a single information space in the system of centralized collection, processing and storage of information and in the automated system of real-time operations control of the plant technological complex, the general discipline of data visualization and dispatching control;
- incorporation into the APCS mathware of control algorithms of technological operation modes and interlocking of equipment at the points of conjugation of the existing technological complex of the I and II stages of the factory and the newly created technological complex of the flotation-filtration, drying-furnace sections and the concentrate storage;
- partial use of the software and hardware of the APCS PP of the first and second stages of the I and II stages for the implementation of the functional systems APCS FFS.

The automated system for centralized collection, processing and storage of information on the technological complex of the flotation-filtration section and ASROC FFS are implemented on the basis of the software and hardware of the existing APCS PP of the first and second stages by expanding its infoware and software.

The designed APCS FFS is a two-level system.

The upper level is a system for the automated system of real-time operations control and technological complexes control of flotation-filtration and drying-furnace sections.

The lower level – automated control systems for technological complexes of flotation-filtration section, drying-furnace section, loading (concentrate storage).

The use of this kind of two-level automation systems has been tested at other coal enterprises and has proven itself well.

5. Technical structure of the system

Scheme of the enlarged technical structure of the ACSP of technological complex for coal loading at the open-pit mine “Barzassky” of “Barzasskoye Tovarishchestvo” LLS at “Barzasskaya” station is shown in figure 2. The implementation of the system is based on microprocessor-based programmable controllers, servers, personal computers and touch panels.

![Figure 2. Scheme of the enlarged ACSP technical structure.](image-url)
Hardware implementation of upper level systems, including existing systems of integrated APCS PP (control system for production processes; engineering support system; system for centralized control and management of first and second loading; centralized collection, processing and storage of information; automated system of real-time operations control of the technological complex of the factory), as well as the designed system APCS FFS (automated control system for technological processes of flotation-filtration, drying-furnace sections and concentrate storage) are performed on the basis of servers and personal computers of the following corporations Hewlett-Packard, DELL, HMI-terminals of Schneider Electric Company.

As the basic software of the upper level of the newly introduced APCS FFS, the existing software package Genesis32 from ICONICS v.9.21 is used. The functionality of this application package is sufficient for the performance of all automated functions, the purchase of additional software modules is not required [8].

The subsystem of the lower level is designed to solve the problems of interconnected control of technological units. In the starting complex it is automated control of the units with observance of the technological regulations of the scheduled start/stop and emergency blocking of the units.

The subsystem is implemented on Omron’s CJ2 microprocessor-based programmable logic controllers and provides: reception and processing of discrete signals about the state of equipment and units, generation of discrete signals for units control, realization of the functions of local, remote and automatic equipment control; reception and processing of signals of the measuring information from local systems of measurement and control of technological parameters; it is possible to receive standard analog and discrete signals; the exchange of data between controllers over a specialized Controller Link controller network; data exchange via the Ethernet information network with the upper level workstations of the system; automated or by commands of the dispatcher formation of start/stop commands in accordance with the current state of the process and units, the requirements of the regulations.

Selection of input-output modules, construction of a system for collecting, processing and transmitting information and control actions were performed in accordance with the scheme of the enlarged technical structure of the system (figure 2), the composition of equipment and assemblies of the technological complex of the factory.

The interconnection of the ACSP controllers with the means for measuring and controlling the parameters of technological processes and the state of the equipment is provided by analog (4-20mA) and discrete (24VDC) signals. To transfer control actions to the control circuits of electric drives, “dry contacts” are used. To ensure galvanic isolation of discrete outputs of controllers, Omron G70A-ZOC16-3 quick mounting system is used.

Lower level systems are built using controllers interconnected by means of Controller Link and Ethernet networks, with the transition, if necessary, to a fiber-optic cable for connecting controllers located in other distribution points.

To interface the ACSP controllers with the means for measuring and controlling the parameters of technological processes and the state of the equipment, as well as the executive devices supporting the exchange of information via the RS485 interface (Modbus RTU protocol), the corresponding interface modules are provided in the controllers.

Information exchange between controllers, devices connected via RS485 to the corresponding Omron controller communication modules, with dispatching stations, with servers and with operator HMI terminals is carried out via the Ethernet information network.

6. Commissioning of the system

The ASROC commissioning is performed in three stages.

At the first stage, the modernized system of automated control and technological complex control of the concentrate storage is put into operation.

At the second stage, the automated control system and the technological complex control of the flotation-filtration section is put into operation.
At the third stage, the automatic control system and technological complex control of the drying furnace section are commissioned, which is supplied in a complete set with technological equipment, including a local system for centralized monitoring and control of drying units.

The task of modernization of the existing automation system is complicated by the fact that the PP is not closed for reconstruction and can not stop for a long time, remaining an active production. In this regard, any changes in the structure and functions of the system should be carried out within strictly limited time of planned maintenance and repair stops.

7. Conclusion
The consistent implementation of these design solutions will create an integrated automated technological complex of the preparation plant with close integration of the existing APCS PP of the first and second stages of the newly created APCS FFS.

References
[1] Myshlyaev L P, Kiselev S F, Ivushkin AA et al 2003 Control Automation of Coal Preparation Plant (Novokuznetsk: SibGIU) p 304
[2] Sazykin G P et al 2003 Designing and Construction of a New Generation of Coal Preparation Plants (Novokuznetsk: SibGIU) p 127
[3] Industrial Automation Systems 2006 ed L P Myshlyaev vol 2 (Novokuznetsk: Science) p 483
[4] Grachev V V et al 2015 Proc. of X All-Russian Sci. Conf. on Automation Systems in Education, Science and Production (Novokuznetsk: SibGIU) pp 90–95
[5] Grachev V V and Shipunov M V 2014 Proc. VI All-Russian Sci. Conf on Automated Electric Drive and Industrial Electronics in the Metallurgical and Mining-fuel Industries (Novokuznetsk: SibGIU) pp 226–232
[6] Ivushkin K A et al 2015 Proc. of Int. Sci. Conf. on High Technology of Development and use of Mineral Resources (Novokuznetsk: SibSIU) pp 203–211
[7] Myshlyaev L P et al 2006 Proc. XV Int. Congress on Coal Preparation (China)
[8] Korovin D E et al 2017 Proc. XI All-Russian Sci. Conf on Automation Systems in Education, Science and Production (Novokuznetsk: SibGIU) pp 254–259