Development of an automated process control system for the coal preparation plant

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Abstract. The experience of modernization of the automated process control system for the coal preparation plant in the conditions of technical re-equipment of the coal preparation plant “Barzasskoye Tovarischeschestvo” LLC (Beryozovsky) is considered. The modernized automated process control system (APCS), the modernization goals and ways of their achievement are presented, the main APCS subsystems and the integrated functional and technical structure of the upgraded system are given. The procedure of commissioning of the upgraded system is described.

1. Introduction

The efficiency of mining enterprises directly depends on the composition and quality of the minerals mined, which cannot be affected. It is possible to increase the quality of the mined mineral, and therefore, the economic efficiency of mining in the process of enrichment, that is why coal preparation plants have been long existing side by side with mines. 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, any modern mining enterprise is a “living” developing system, constantly changing the technological structure and automated process control system, accordingly. So, the coal preparation plant “Barzasskoye Tovarischeschestvo” LLC (Beryozovsky) started as a reloading station with the simplest sorting functions and currently it is a complex integrated enterprise that includes technological processes in the following branches:

- coal reception and coal preparation;
- coal enrichment in the main building, including dense medium separation, thickening and dehydration, etc.;
- flotation-filtering department;
- drying department;
- storage and loading.

2. Brief characteristics of the control object

Within the current stage of technical re-equipment, two departments have been re-equipment: flotation-filtering department and drying department, also the existing technological complex of the concentrate storage was modernized [1].
The operating coal preparation plant is a complex facility with various technological equipment, continuous handling lines with their territorial distribution. Technological processes are automated, and the task of modernization includes, among other things, a targeted change in the existing automated system that allows the automation of newly introduced equipment and technological processes with minimal material and time costs to be implemented without disrupting the overall system performance.

The next stage of re-equipment is the modernization of the enrichment processes taking place in the main building and the completion of a new intermediate module between coal receiving and enrichment in the main building with the addition of a dense medium separation facility.

At present, the modernization of the technological complex is closely linked with the modernization of automation systems of the corresponding technological processes.

The integration of the APCS of the reconstructed loading complex and the projected APCS of the coal preparation plant under construction is ensured by

- creation of a single information space in the system of centralized collection, processing and storage of information in the automated system of operational dispatch control of the plant technological complex, the general discipline of data visualization and dispatching management;
- inclusion of the control algorithms of technological regimes coordination and mutual blocking of equipment at the connection points of the existing and projected technological complex in the APCS mathematical support;
- partial use of the APCS software and hardware of the reconstructed loading complex for the implementation of APCS functional systems of the coal preparation plant under construction.

The APCS, implemented within the framework of modernization, is intended for complex automation of control and control over production and technological processes, equipment of the re-equipped loading facility and the coal preparation plant, including the solution of the following additional tasks (taking into account the fact that the existing system fully performs the functions assigned to it and does not require the modernization of any component): centralized control, analysis and display of information about the state of production and technological processes and equipment of the coal preparation plant and the reconstructed loading complex.

3. The purpose of the system development

The purpose of modernization is to increase the efficiency of the enrichment process by integrating the following components into a single APCS: the systems of complex control at the flotation-filtering department, drying department, concentrate storage, as well as modernization of the department for coal receiving and loading and the main building. As a result, technical and economic indicators of its functioning improve: the unit costs for production decrease, the yield of product increases and the quality of mark products improves.

The set goal is achieved in the following areas.

1. Automation of information and control functions in solving problems of: immediate formation and analysis of information on changes in operation modes and condition of technological processes, units and equipment; immediate consistent correction of tasks according to the mode parameters of technological processes; immediate implementation of control decisions and regulation of technological parameters; control, recording and analysis of technological and production discipline violations, control effectiveness.

2. Improvement of reliability of the automated process control system, efficiency and quality of control due to: the use of modern technical means, methods and algorithms of automatic control, analysis, diagnostics 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 of modern microprocessor controllers with high reliability, long operation time between failures as a technical base on the lower level of the system, simple replacement of failed components, expansion of technical structure, modification of
mathematical support and software; minimization of the number of unreliable electromechanical devices in local systems of logical control and control over individual mechanisms and assemblies.

4. Functional structure of the system

The automated process control system at floating-filtering, drying departments and concentrate storage (APCS FFD) is developed as a component part of the integrated automated process control system at the coal preparation plant and the reconstructed technological facility of coal loading (APCS CPP) of “Barzasskoye Tovarischchestvo” LLC on the basis of the existing software and hardware of the APCS CPP operating in the technological complex of enrichment of the I and II stage and the loading facility.

The designed APCS are developed taking into account the maximum possible use of the resources of the already existing technical means of APCS, unification of the software and hardware of the projected and operating APCS. All previously commissioned and newly designed APCS of technological complexes are connected through a common interface, unified hardware and a uniform approach to the control of both local units and complexes as a whole.

The enlarged functional structure of the integrated APCS CCP is shown in figure 1, a. It consists of the following main systems:

1) the existing APCS CPP of the first and second stages, that includes
   - an automatic system for the centralized collection, processing and storage of information of the coal preparation plant (CPP);
   - engineering support system;
   - automation control system of production (ACSP);
   - automated dispatch control system (ADCS) of the CPP technological complex;
   - local system of centralized control and loading control;
   - systems for automatic control and control of technological complexes (ACS TK) of coal receiving facility, enrichment and loading of the I and II stages of the factory;

2) projected APCS CPP, that includes
   - automatic system of the centralized collection, processing and storage of information of the floating-filtering and drying-furnace departments;
   - automated dispatch control system of the technological complex of the floating-filtering and drying-furnace departments (ADCS FFD and DFD);
   - system of automatic control and loading control of the newly installed equipment at the concentrate storage facility;
   - system of automatic control and technological complex control of the floating-filtering department (SAC TCC FFD);
   - system of automatic control and technological complex control of the drying-combustion department, supplied alongside with the technological equipment, including the local system of centralized control and control of drying units (SAC TCC DFD).

The enlarged functional structure of the automated process control system of the reconstructed technological complex for coal loading and the coal preparation plant being built is given in figure 1, b. It consists of the following main systems

1) the reconstructed APCS for the loading complex, that includes
   - the system of centralized collection, processing and storage of information of the reconstructed loading complex;
   - engineering support system;
   - industrial process control system;
   - automated dispatch control system (ADCS) of the reconstructed loading facility;
   - local system of centralized control (enrichment module);
   - systems for automatic control of the existing enrichment and coal receiving facilities;
   - system of automatic control of the main building;
Figure 1. Schemes of the functional structures of integrated APCS CPP of “Barzasskoye Tovarischchestvo” LLC.
2) the projected APCS of the coal preparation plant under construction, that includes
   • system of the centralized collection, processing and storage of information of the enrichment module No. 1;
   • automated system of dispatch control of the enrichment module No. 1;
   • system of automatic control of the newly installed equipment in the main building;
   • system of automatic control of the enrichment module No. 1.

The automatic system of centralized collection, processing and storage of information on the technological complex of the floating-filtering department and the ADCS FFD is implemented on the basis of the software and hardware of the existing APCS CCP of the first and second stages by expanding its information support and software.

The projected APCS is a two-level system.

The upper level
   • automated system of dispatch control and control of technological complexes of the floating-filtering and drying-furnace departments;
   • automated system of dispatch control of the enrichment module No. 1.

The lower level
   • automatic control systems for technological complexes at the floating-filtering department, drying-furnace department, loading facility (concentrate storage facility).
   • system for automatic control of the enrichment module No. 1, the system for automatic control of the newly installed equipment in the main building.

The application of this kind of two-level automation systems has been tested at other coal industry enterprises and has proved its efficiency.

5. Technical structure of the system

The Scheme of the enlarged technical structure of the automated process control system of the technological complex at the coal loading facility and the coal preparation plant of the open pit mine “Barzasskiy” is presented in figure 2. The scheme of the enlarged technical structure of the automated process control system at the flotation-filtering and drying-furnace departments is given in [1]. The system is based on microprocessor programmable controllers, servers, personal computers and touchpads.

The hardware implementation of the upper-level systems, including existing systems of the integrated APCS CPP (control system for production processes, engineering support system, system for centralized control over the I and II loading stages; system of the centralized collection, processing and storage of information; automated dispatch control system and control of the technological complex of the plant), as well as the projected system of the APCS FFD (the automated control system for technological processes, flotation-filtering, drying-furnace departments and a concentrate storage facility) are executed on the basis of servers and personal computers of corporation Hewlett-Packard, DELL, HMI-terminals by Omron.

The existing software package Genesis32 from ICONICS v.9.21 is used as the basic software of the upper level of the newly introduced APCS FFD. The function characteristics of this software package is sufficient to perform all the automated functions, the purchase of additional software modules is not required.

The lower-level subsystem is implemented in microprocessor programmable logic controllers CJ2 by Omron and provides: reception and processing of discrete signals about the state of equipment and units, generation of discrete signals for units control, realizing the functions of local, remote and automatic control of unit equipment; 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 via a specialized controller network Controller Link; data exchange via the Ethernet information network with workstations, with servers and with HMI terminals of the upper-level system; the formation of
start/stop commands of the units automatically or by commands of the dispatcher in accordance with the current state of the process and units, the regulations requirements.

Figure 2. Scheme of the enlarged technical structure of the APCS CPP.

The selection of input-output modules, construction of a system for collecting, processing and transmitting information and control actions are based on the scheme of the enlarged technical structure of the system (figure 2), the composition of equipment and units of the plant technological complex.

The interconnection of the APCS 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. The quick mounting system Omron G70A-ZOC16-3 is used to ensure galvanic isolation of discrete outputs of controllers.

6. System installation

The APCS was put into operation in the following way.

At the first stage, the upgraded automatic control and management system for the technological complex of the concentrate storage facility was put into operation.

At the second stage, the automatic control system of the technological complex at the floating-filtration department was put into operation.

At the third stage, it is planned to put into operation an automatic control system for the technological complex of the drying-furnace department, supplied alongside with technological equipment, including a local system for centralized control of drying units.

The further reconstruction includes the addition of new enrichment modules and modernization of the existing ones with the subsequent integration of all APCS CPP into a single system with a centralized control.

The task of modernization of the existing automation system is complicated by the fact that the CPP is not closed for reconstruction and cannot be stopped for a long time remaining an active production.

The automation system put into operation within the framework of the reconstruction is directly connected with the existing technological complex and its control system, for example, an automated system of dispatch control. Integration of the newly introduced system with the existing system must
be performed on the stopped technological equipment.

However, in practice, the approved production plans allow the production equipment to be stopped only for the performance of preventive maintenance (PM), which is often not enough to perform integration and maintenance procedures. Thus, the commissioning of the updated automation systems is done piece by piece during the PP works, competing in time with the work carried out by the maintenance personnel of the production facility. This significantly delays the commissioning period [2].

Therefore, it is more rational to start the modernization of the system from the formation and installation of cabinets with new equipment, given the close integration of the installed equipment with the existing one. Then, step by step (either by units or by technological subsystems) to transfer the functions of the old system to the new one with the possibility of parallel operation of both systems. Dismantling of obsolete equipment is done in the end, only after the new system is put into operation.

When the control cabinets are ready and the signal lines from the control panels of the units to the PLC cabinets are completed the following is performed

- the alternate inclusion of temporary control schemes of process units that can be stopped for commissioning; and it is necessary to provide for the possibility of functioning of part of the units under the control of the old system, and part of the units – under the control of the new system;
- with the time scheme, the control of the upgraded units is transferred to the controller, however, for the purposes of units control, the signal lines of the old system are used; the overall control of the technological complex and other units remains unchanged, the control also remains on the existing mimic diagram; at this stage, the debugging of the software of the system being put into operation is performed;
- after debugging the software of the controllers of all units, a transfer to the final control scheme of the units;
- when the means of upper level control (SCADA-system) are ready, the dispatching control is transferred from the mimic diagram to the workstation;
- after debugging the local control system of each unit, the control of the whole technological complex is transferred with the help of the controllers of the updated automated control system.

7. Conclusion
The application of this kind of phased modernization, on the one hand, requires a great deal of time to put the updated system into operation, on the other hand, it allows all routine maintenance of the system modernization to be performed without long stops of technological equipment [3].

An important positive factor for the creation of the APCS CPP of “Barzasskoye Tovarischeshestvo” LLC is the understanding by the customer of the need for the consistent development of a control system by the specialists of one organization providing uniform solutions for software, technical, algorithmic, and information support and maintenance of the previously adopted principles at all levels of control.

Even in the presence of a large number of local automation systems, it is necessary to ensure that the uniform designations and approaches adopted in the single space of the APCS CPP are used to give the operator an opportunity to concentrate on performing his basic functions, rather than studying heterogeneous interfaces of local control systems or individual complexes provided by different suppliers, that are not always can be integrated into a single environment. Analyzing the accumulated experience [4-6] it can be clearly seen that it is necessary to carry out the reconstruction of one stage with regard of the APCS further development and to make decisions taking into account the subsequent “seamless” integration of the created subsystems into a single modern control system at a complex multi-stage production such as “Barzasskoye Tovarischeshestvo” LLC.
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