Development of automated control system for the mineral processing plant in the process of modernization

Development of automated control system for the mineral processing plant in the process of modernization

M V Lyakhovets[1], K G Wenger[2], L P Myshlyaev[1], M V Shipunov[3], V V Grachev[1] and G V Makarov[1]

[1]Siberian State Industrial University, 42 Kirova str., Novokuznetsk, 654007, Russia
[2]"Stroyservis" CJSC, 121 Kuznetskiy ave., Kemerovo, 650055, Russia
[3]"Scientific-research Center for Control Systems" LLC, 42 Kirova str., Novokuznetsk, 654007, Russia

E-mail: mail@nicsu.ru

Abstract. The experience of retrofitting the automated process-control system at the mineral processing plant in the conditions of reconstruction of the mineral processing plant LLC JV "Barzasskoye Tovarishchestvo" (Beryozovskiy) is considered. The automated process-control system (APCS), retrofitting goals and ways to achieve them are indicated, the main subsystems of the integrated APCS are presented, and the enlarged functional and technical structure of the upgraded system is presented.

1. Introduction

The development of a modern industrial enterprise, especially in the field of mining and minerals processing, is inextricably linked with an increase in the production capacity, reduction of unit costs and improvement of the finished products quality. The processing plant of the LLC JV "Barzasskoye Tovarishchestvo" (Beryozovskiy) is no exception. At the moment the reconstruction of the enterprise with increased production capacity and quality indicators of the preparation of coals mined at the open-pit mine "Barzasskiy" is being completed. Retrofitting of a modern technological complex, on the other hand, is connected with the retrofitting of automation systems of the corresponding technological processes [1, 2].

As part of the reconstruction of the processing plant (PP), it is planned to create a new compartment for the preparation of coal in a two-product dense-media wheel separator and the modernization of the existing ones – the compartment of coal reception and coal preparation; technological complex of the PP main building. The existing processing plant is a complex object with a variety of technological equipment, sequenced-flow transport lines and their territorial distribution.

At the same time the technological processes are automated, and the task of retrofitting lies, among other things, in the targeted change in the current automated system, which makes it possible to introduce automation of newly installed equipment and technological processes without disturbing the operation of the entire system with minimal material and time costs.

2. Goals and objectives of APCS retrofitting

The automated process control system (APCS) implemented within the framework of the reconstruction is intended for the integrated automation of control over the production and technological processes, equipment of the retrofitted processing plant, including the solution of the

following additional tasks: centralized control, analysis and display of information on the state of production and technological processes and the equipment of technological complexes of the newly built compartment and modernized compartments; automated control of technological processes and equipment of the reconstructed technological complexes.

The goal of retrofitting is to increase the efficiency of control of the coal preparation technological complex and, as a result, to improve the technical and economic indicators of its operation: a reduction in the unit cost of production; increase in the output of a product; as well as improvement in the quality of commercial products.

This goal is achieved in the following areas: automation of information and control functions; improvement of the reliability of the automation control system of the technological complex, efficiency and quality of control. When controlling the technological complex of coal preparation, the following main objectives are expected to be solved by the projected system:

- automatic control and control of the state of equipment and units, technological complex of coal preparation (in terms of newly installed equipment).
- automatic measurement, control and regulation of operational parameters of the technological process: coal preparation in dense-media hydrocyclones; sludge enrichment in spiral separators; enrichment in the dense-media drum separator; enrichment in the dense-media wheel separator SKVP-20; cake loading; unloading from a concentrate warehouse.

The task of monitoring and controlling the state of the equipment and units that make up the sequenced-flow transport systems of individual technological complexes and the plant as a whole is quite simple from the point of view of automation of the control functions.

The automation system is expected to perform logical control, diagnostics and control of the state of individual units and the technological scheme as a whole, based on the commands of the operators of the respective complexes and the plant dispatcher (start/stop of the technological complex), requirements of the process regulations, equipment safety and safety of its operation. However, its implementation is the most costly, due to the complexity of this task, due to the large number of equipment and components.

Particularly considering the fact that this PP is already undergoing the fourth major modernization [3, 4] associated with changes in technological schemes of coal preparation, which resulted in changes in the APCS structure, the composition of the application software. Thus, the implementation of such procedure as a scheduled start-up of the units of the sequenced-flow transport systems becomes a rather complicated task of coordinating the start-up sequence of the units in a distributed network of controllers with a large number of interlocks of the production equipment of the technological complexes.

3. Functional structure of integrated APCS

Automated control system of technological units of the PP compartment under construction and the reconstructed process complex of coal loading (APCS PM) is being developed as a part of the integrated automated process control system of the processing plant (APCS PP) LLC JV “Barzasskoye Tovarishchestvo”, based on the existing hardware and software of the functioning APCS PP of the technological complex for coal preparation of I and II stage and the loading complex.

The designed APCS MO is developed taking into account the maximum possible use of resources of the already existing technical means of APCS PP, unification of software and hardware of the designed APCS MO and operating APCS PP technological complex of coal preparation I and II stages.

The enlarged functional structure of the integrated APCS of PP is shown in figure 1.

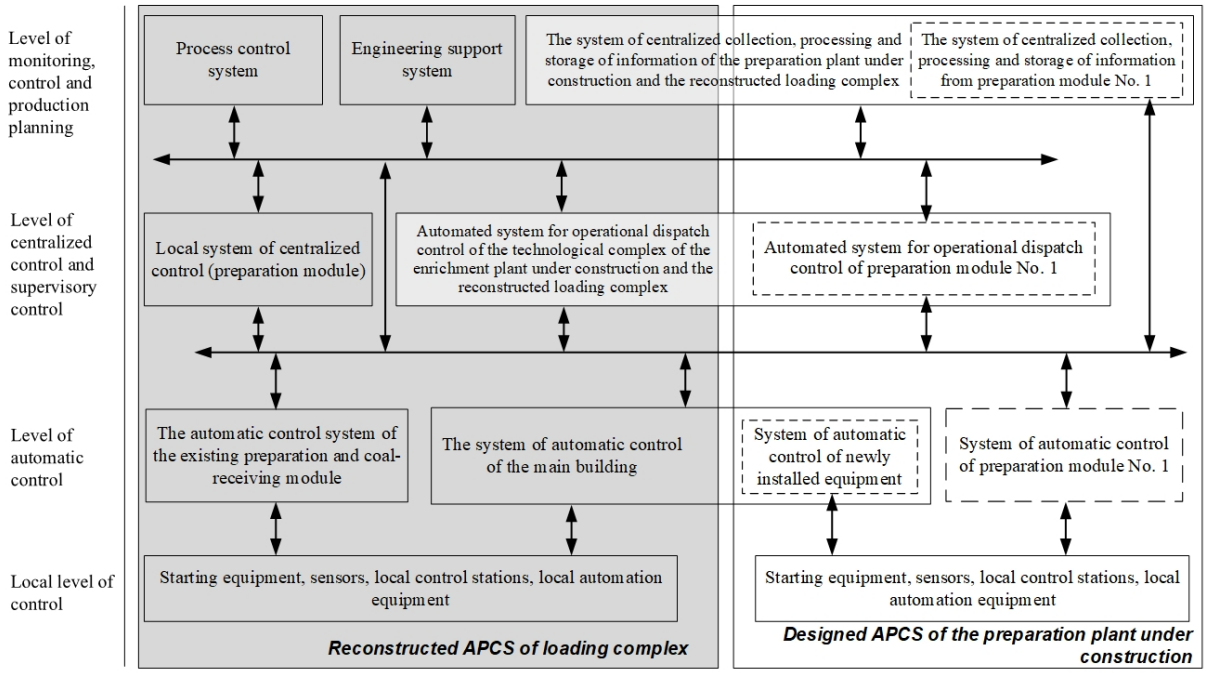

Figure 1. Diagram of the functional APCS structure of the reconstructed technological complex for coal loading and the processing plant under construction.

It consists of the following main systems:

1) reconstructed APCS of the loading complex, including:

- a system of centralized collection, processing and storage of information of the loading complex under reconstruction;
- engineering support system;
- process control system;
- automated dispatch control system (ADCS) of the loading complex under reconstruction;
- local centralized control system (preparation module);
- systems of automatic control of the existing preparation and coal reception module;

- систему автоматического контроля и управления главным корпусом;
- пусковая аппаратура, датчики, средства локальной автоматики реконструируемого комплекса погрузки (уровень «полевых» устройств).
- system of automatic control of the main building;
- starting equipment, sensors, local automation equipment of the loading complex under reconstruction (the level of “field” units).

2) the designed APCS of the constructed PP, including:

- a system for centralized collection, processing and storage of information of preparation module No. 1;
- automated system of operational and dispatching control of preparation module No. 1;
- system of automatic control of newly installed equipment of the main building;
- automatic control and monitoring system of preparation module No. 1;
- starting equipment, sensors, local automation equipment of preparation module No. 1 and newly installed equipment of the main building (the level of “field” units).

The integration of APCS of the reconstructed loading complex and the designed APCS of the constructed plant and the creation of an integrated automated technological complex of the processing plant 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 operational dispatch control of the technological complex of the factory, general discipline of data visualization and dispatch control;
- inclusion of control algorithms of technological modes and equipment interlocking at the interface points of the existing and planned technological complex into the software package of APCS;
- partial use of software and hardware of APCS of the reconstructed loading complex for the implementation of the functional systems of APCS PP.

The system of centralized collection, processing and storage of information and the ADCS module of preparation No.1 is implemented on the basis of the software and hardware of the existing APCS of the reconstructed loading complex by expanding its information support and software.

4. Technical structure of APCS

The designed APCS PM is a two-level system.

The upper level is the automation system for operational and dispatching control of preparation module No.1.

The lower level is the system of automatic control of preparation module No.1, the system of automatic control of the newly installed equipment of the main building.

The diagram of the enlarged APCS technical structure of the reconstructed technological complex for loading coal and the processing plant under construction is presented in figure 2. The hardware implementation of the system is based on microprocessor-based programmable controllers, servers, personal computers and touch panels.

5. Hardware and software

Hardware implementation of the upper level systems, including the existing systems of the integrated APCS PP (production process control system; engineering support system; local centralized control and system (preparation module); system of centralized collection, processing and storage of information of the reconstructed loading complex; automated dispatch control system of the reconstructed technological loading complex) as well as the designed APCS PM (centralized collection, processing and storage of data on preparation module No.1; a automated dispatch control system of preparation module No. 1) are based on servers and personal computers of Hewlett-Packard, Dell, Omron HMI terminals.

The current Genesis32 software package from ICONICS v.9.21 is used as the basic top-level software of the newly introduced APCS PM.

The functionality of this application software is sufficient to perform all automated functions.

6. The subsystem of the lower level

The subsystem of the lower level is designed to solve the problems of interrelated control of technological units. In the start-up complex it is an automatic control of the units in compliance with the technological regulations of the scheduled start/stop and emergency blocking of the units.

The subsystem is implemented on Omron microprocessor-based programmable logic controllers of CJ2 series and provides: receiving and processing discrete signals about the state of equipment and units, generating discrete control signals for units, realizing the functions of local, remote and automatic control of the unit's equipment; reception and processing of measurement information signals from local systems that measure and monitor technological parameters; the possibility of receiving standard analog and discrete signals; data exchange between controllers via a specialized controller network Controller Link and an information Ethernet network; data exchange via an Ethernet information network with top-level workstations of the system; automatic or according to the

dispatcher's commands, the formation of start/stop commands for the units in accordance with the current state of the process and units, requirements of regulations.

The selection of input/output modules, the construction of a system for collecting, processing and transmitting information and control actions are made on the basis of the scheme of the enlarged technical structure of the system (figure 2), the composition of equipment and components of the PP technological complex.

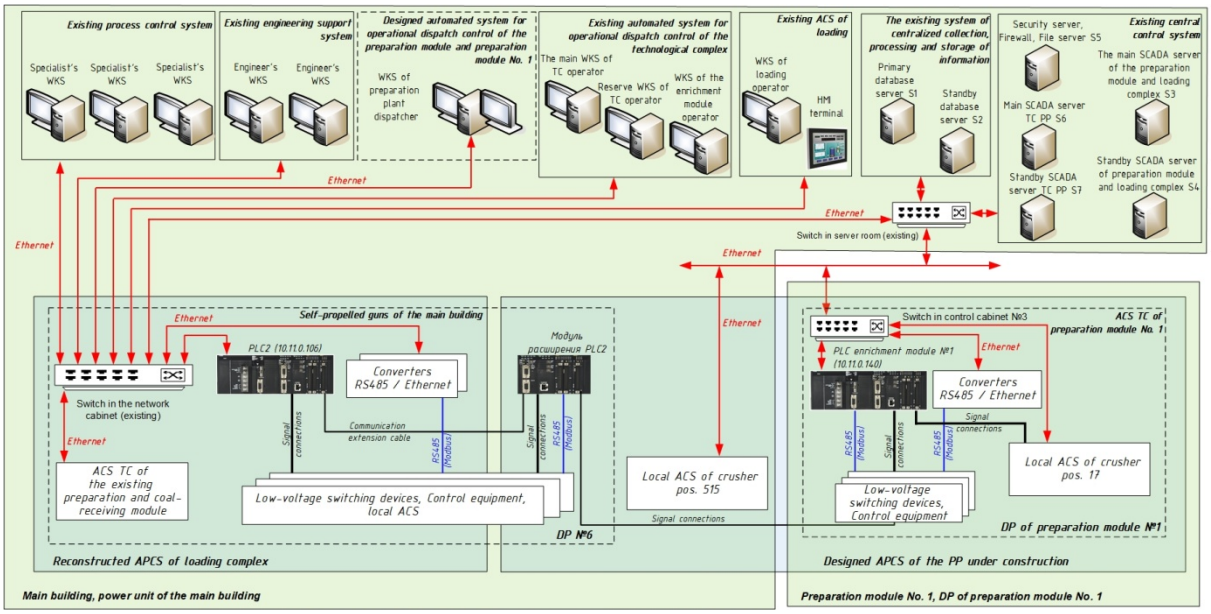

Figure 2. Diagram of the enlarged APCS technical structure.

The pairing of APCS controllers with the means of measurement and control of the technological processes parameters and the state of the equipment is provided by analog (4-20mA) and discrete (24VDC) signals. "Dry contacts" are used to transfer control actions to electric drive control circuits. To ensure the galvanic isolation of the controllers discrete outputs of the, the Omron G70A-ZOC16-3 quick mounting system is used.

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

For interfacing APCS controllers with the means of measurement and control of the technological processes parameters and equipment condition, as well as actuators that support the exchange of information via the RS485 interface (Modbus RTU protocol), the corresponding interface modules are provided as part of the controllers.

Information is exchanged between controllers, with devices connected via RS485 to the corresponding communication modules of Omron controller, with dispatch stations, servers and operator HMI terminals via Ethernet information network.

7. Conclusion

The task of retrofitting the existing automation system is complicated by the fact that the processing plant is not closed for reconstruction and cannot 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 in a strictly limited time of scheduled stops of maintenance and repair. In addition, the presence of a distributed network of industrial controllers (commissioned at different times) imposes certain restrictions on the implementation of data exchanges through heterogeneous information networks, as

well as piecewise-distributed software realization of routine procedures for starting and stopping units included in the production chains of technological complexes.

The consistent implementation of these design solutions allowed a complete automated technological complex of the processing plant to be created with close integration of the existing a APCS PP and the newly created APCS PM.

Acknowledgments
The work was carried out according to the State Assignment of the Ministry of Science and Higher Education of Russia No. 8.8611.2017 / 8.9.

References

[1] Sazykin G P et al 2003 *Design and Construction of Coal Processing Plants of New Generation* (Novokuznetsk: SibSIU) p 126
[2] Myshlyaev L P et al 2003 *Automated Control of Coal Processing Plants* (Novokuznetsk: SibSIU) p 304
[3] Lyakhovets M V et al 2017 *Proc. of the XI All-russian Sci. Conf. on Automation Systems in Education, Science and Production* (Novokuznetsk: SibSIU) pp 151–156
[4] Lyakhovets M V et al 2017 *Proc. of the XI All-russian Sci. Conf. on Automation Systems in Education, Science and Production* (Novokuznetsk: SibSIU)