

AUTOMATION AND CONTROL SYSTEMS ON OKD'S COAL MINE PREPARATION PLANTS

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ABSTRACT

The paper informs about control and information systems operated in OKD a. s. and ČMD a. s. (joint stock coal mine company) coal mine preparation plants in the Ostrava-Karviná region. ATP Soukup Ltd. has become the leading manufacturer and supplier of these systems to OKD and is also a major supplier of measuring, regulating, and control equipment for coal preparation. ATP Soukup, being familiar with the state-of-the-art coal preparation technology and using the latest knowledge of technological process control, has developed comprehensive control systems used in coal preparation plants. The paper analyses in more detail particularly the coal preparation control systems used in the Důl Lazy, Důl Darkov, and Důl ČSM coalmines. In the above mentioned coal preparation plants, also sales control systems have been implemented built upon existing coal preparation plant control systems that cover the area of product quality assurance. These systems are powerful tools that the coal preparation plant workers may use to optimize production and assure product quality to meet the ISO 9000 standards.

Keywords: automation, control systems, coal preparation plant

1. CONTROL SYSTEM LEVELS AND CONCEPTION OF THE CONTROL SYSTEM

For all the implementations of our control systems in coal preparation plants, the decisive factor was the control of the key preparation technologies such as flotation, jigging and heavy-liquid separation as well as the control of dewatering and storing technologies. The solution of local technology control paved the way for controlling a coal preparation plant as a whole, monitoring the performance and efficiency of each technology, controlling the key quality parameters, recording the output of the entire coal preparation plant per hour, shift, and day as well as calculating the key economic figures. The installed coal preparation plant control system could be used as a basis for sales control. The technological process of storing the washed coal is directly linked to the process of loading and transport and, in co-operation with shipping and receiving departments it forms a sales control department. The sales control is then closely followed by quality control, which goes back against the flow of material through the whole coal preparation process.

ATP Soukup Ltd. has adopted the following distinction of control levels for building the system: *process level, production management (dispatching) level and top management level*. The terminology is based on the degree of participation of man in the control process.

2. AUTOMATIC CONTROL OF THE MAIN TECHNOLOGICAL NODES

As part of the system installation, the main technological nodes were automated. Here are some examples of technological nodes automated by ATP Soukup:

The **flotation process** is controlled by dosing the flotation agent according to the ash content of the flotation gangue with a correction using the rate of flow and the specific mass of the input raw material. As a stabilising element for the main control circuit, the level in the flotation machine is regulated by controlling the flotation gangue output. The flotation control has been developed over a long period. The original local control in an analogue version was replaced by direct computer-based control, which allowed easy setting of technological parameters or a change of algorithm in the event of considerable changes in the raw material. The implementations in coal preparation plants are always tailored to the local conditions, the flotation machine type, the requirements of sludge management and dewatering systems.

In the ČSM Coal Preparation Plant, the ŠKODA **jigs** are used with air distributed by turning slide valves. When we were installing the control system, we reconstructed them [1]. To allow for multiple pulsations, we replaced the turning slide valves by disk valves controlled by membrane valves. A technological computer enables, apart from single, double, and triple pulsation, control of the incoming air pressure, water quantity, and the height of the bed in each field of the jig. The computer also provides automatic control of elevation. In the ČSM Coal Preparation Plant, in 1994 – 1996, five jigs were gradually reconstructed. Double pulsation was used for them.

We have also automated the jigs (mostly of the OM type manufactured in Russia) in other coal preparation plants. In 2000, ATP Soukup automated the jig control in the Darkov Coal Preparation Plant. Here the control system is based on the modular AMiT system. The implementation consists in installing several control loops. The unit itself forms the automatic pulsation control in the jig. Several pulsation types can be selected: simple pulsation where the pulse rate per minute can be controlled or multiple pulsation with the cycle period set in seconds. In addition, the system allows for further control loops: automatic control of heavy product raising, automatic bed elevation, air pressure control in jig field collectors, and bottom water flow control.

In **heavy-liquid separation control** the original hydrostatic method for measuring the specific mass of the washing suspension (that is, controlling the density by adding water or float-controlled fresh suspension) was replaced by our system of measuring the quantity of ferromagnetic heavy medium in the suspension. This method was implemented in all OKD coal preparation plants except the Jan Karel plant. The output is an electric signal that, after gauging, represents the value of the specific mass of the suspension and is the basic control quantity – adding fresh washing suspension or water. This also includes control of levels in circulation pits of the first and second separating sections and in the pit for the diluted liquid. The set values of the separation section are maintained with a tolerance of $0,01 \text{ kg.dm}^{-3}$ and they are controlled and recorded by the control system like in flotation.

3. SYSTEMS OF COAL PREPARATION PLANT CONTROL

The development of each of these control systems was part of a large project aiming to provide a comprehensive solution of technological processes up to the production management level. Its implementation comprised the following areas: modernizing and completing the sensor equipment, finding solution to automatic control of the main technological nodes and building an automated control and information system.

The ATP Soukup control system operates about 1200 to 1600 analogue, binary and counter sensors. Part of the sensors customised for coal preparation plants are the company's own development. Typical analogue sensors are, for example, those measuring the specific mass of sludge and magnetic suspensions, continual ash meters on conveyers, ash meters for flotation gangue, current load values for conveyer weighers, turbidity meters, meters of magnetic proportions in suspensions, machine load meters, and level indicators. Binary sensors are mostly point level indicators, machine contactor contacts or end switches. They form the bulk of the sensors involved in the system. Counter sensors are used, for example, to register the output from a conveyer weigher. Data are collected from the sensors in data concentrators.

All the sensors and local controls of technological nodes are connected to the coal preparation plant control system. An **Alpha controlling computer** forms the heart of the system running with the real-time **VMS operating system**. To implement these systems we used the hardware and software platform developed by Digital (Compaq since 1998) since this platform is very suitable for use in real-time processing because of its performance, robustness, considerable stability and safety [2].

The output device serves as user interface. The basic output unit is a so-called **terminal group**. This is a set of devices whose minimum configuration comprises an operation terminal, an alarm terminal, printer, and a graphic station. Currently, up to 16 terminal groups can be connected to a system configured accordingly. Under the term graphic station we understand a PC equipped with the **Promotic SCADA/HMI** visualisation software developed by Microsys Ostrava, with applications of a visualising technology. A graphic station displays technological diagrams and allows the plotting of selected quantities.

Our system is characterised by **modularity and multi-layer feature** [2]. Thanks to its modularity the system allows easy modifications of its scope and behaviour and new modules being added to meet the customer's demands (modules for maintenance, machine downtimes, etc.). The layers separate the functional blocks of the system, which communicate with each other via a data interface. From the user's point of view, the "data collection", "alarm", and "presentation" layers are important. The data collection layer processes the data supplied by sensors through data concentrators.

The system accesses each sensor separately, which means that each sensor uses its own methods of conversion, averaging, and linking to other sensors. Each value is verified in relation both to the sensor's basic properties and to other technologically similar sensors. This ensures that other layers can work with verified information on the technological process. The alarm layer allows monitoring, assessment, and reporting of non-standard situations occurring during a technological process. It is also important that only messages reporting on really significant deviations should be produced by the system. For this reason, several mechanisms have been introduced to filter out short-term alarms or those not important in terms of system control. The triggered alarms are displayed, acknowledged, and archived.

At present, ATP Soukup operates control systems in coal preparation plants of the **Důl Lazy** (1997) **Důl Darkov** (1998) and **Důl ČSM** (2001) mines. A control system was also operated in the coal preparation plant of the **Důl František** mine. However, this preparation plant was closed down in 1998 as part of a government reduction scheme.

4. SALES CONTROL SYSTEMS

The sales control system developed by ATP Soukup is a **database-oriented system with a Microsoft SQL server** with Windows NT as its core [2]. The three systems we have implemented in OKD a.s. coal preparation plants are operated on computers with Alpha processors. At the time the system was designed (1995/96), the configurations with these processors were somewhat more expensive as compared with the solutions using the Intel platform but their performance, reliability, and stability was considerably higher.

We put three sales control systems into operation, namely in the **Důl ČSM** (1996), **Důl Lazy** (1997), and **Důl Darkov** (1999) coal mine preparation plants. The system clients – standard PC's with Windows 95 - are equipped with applications installed as needed. Let us mention at least the most important of these applications: daily overviews by ranges of products, customers, real-time loading, monthly loading statistic, marketing quality parameters, real-time train loading, monthly reports on marketing quality, statistics of loaded product quality measurements with the Wilpo quick analyser, daily loading schedule, preparation and printing of bills of freight and journey reports for export and inland, decade and monthly fuel quality reports, arbitration recording, summary of loaded wagons, statistic of loaded lorries, etc. An independent part of the system is the connection to organisations that, even though external, are an integral part of shipping and marketing. Without these organisations, the system would be incomplete. Along this line, the most advanced system is installed in the **Důl ČSM** coal preparation plant [1], which is connected to OKD Doprava (transport company) and to the shipping department. The sales and shipping system, in turn, feeds the preparation plant with data used to print bills of freight and journey reports for shipped wagons.

5. CENTRAL OKD SALES CONTROL SYSTEM

In February 2000 we started work on further development of these systems aiming to establish links to the **central OKD sales control system** based on SAP R/3 system. This sales control system covers six coal preparation plants nowadays.

In 2001 I also developed a model of sales and shipping operative control in OKD [3]. The difficulty of creating the models in coal preparation mainly results from complexity of the modeled subject. Each coal

preparation plant has a different topology of the operation, different raw and washed coal warehousing capacities, different technologies used for separation and different structure of the treated coal. There is a number of effects of random and unpredictable character occurring during the coal processing and the coal preparation plant product shipment and sale. Another important visual angle is what is the optimization criterion, whether the coal preparation efficiency itself or the sales optimization. I thoroughly analyzed the sales activities in OKD, including the sales and shipping operative control, as well as the complex sales control including forecasting and balancing. The analysis shows that the availability of sensors and automation in the operation at the level of process and dispatch is sufficient in OKD, establishing conditions for subsequent creation of systems supporting the control at the managerial level (and therefore including the sales control). The operative sales control consists in the loading and shipping control, as well as in meeting the product quality parameters to meet the customer's requirements, with simultaneous effort to achieve an optimum production of the coal preparation plant.

I used the data models to draft the implementation model (by describing the relational SQL database structures). The proposed structures contain a complete description of the information content required to record the sales trend. This allows presenting the loading and shipping trends in real time, including the quality parameter check, which is the basic tool for inspection and indirect sales operative control. I utilized the proposed structures in practice during the "BOS Sales" information technology system implementation at the beginning of 2001 (implementation was complete in September 2001). The implementation of my model was not complete due to unilateral orientation of the system to the business part of sales and an excessive specialization, so the model verification is only partial. However, based on experience from designing and implementing the sales information technology system in the ČSM coal preparation plant (1996) and from certain tasks in the product quality monitoring in Darkov coal preparation plant (1999), in my opinion, the model can be fully implemented and is sufficient as far as its basic function – cognition – is concerned.

6. BENEFITS FROM SYSTEM INSTALLATION

The benefits the system installation will bring should be assessed from several angles. The simplest evaluation uses the direct economy of profit brought by installing the automated control of technological nodes. For example, in the Důl ČSM coal preparation plant, the introduction of flotation control clearly raised the quality of the flotation concentrate and resulted in considerable economy in the consumption of flotation agents. With the automation of separation in the ČSM jigs, an increase of 1.9 % in the washed product yield could be clearly observed (based on an analysis made by VŠB TU Ostrava). Thanks to these two items alone, the investment in the entire control system returned in less than a year [1].

Another benefit is the permanent monitoring of maintaining technological discipline. The permanent inspection of a technological process allows the controllers to detect any deviation from the technological regulations, to analyse them and remove the cause. The coal preparation plant control system significantly extends the scope of unbiased information on the operation and enables real-time monitoring of the process. It makes it possible to record the progress of each technological process. It guards the exceeding of watched limit values. It processes control and statistical data. By presenting the results of monitoring technological processes in coal preparation plants and sales departments, the company management receives sufficient data to be used for production analyses, quality assurance of the manufactured products and their marketing. Thus they are in possession of a powerful tool for production optimization and quality assurance meeting the ISO 9000 standards.

7. REFERENCES

- [1] Danel, R. & Skotnica, J.: Information and Control System of ČSM Coal Mine Preparation Plant, Mine Planning and Equipment Selection MPES '97 , p. 608-613. VŠB - TU Ostrava, ČR, 1997.,
- [2] Danel, R.: Information Systems in OKD and ČMD Coal Preparation Plants, International Carpathian Control Conference ICCS '2001, p. 125-132, Krynica, Poland, 2001.,
- [3] Danel, R.: Analysis and Model of the Sales Shipping Operative Control in OKD and ČMD, Thesis Works, VŠB – TU Ostrava, Ostrava, ČR, 2001.