Process Control System of the Converters Plant in the RTB Bor Company, Serbia

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Abstract – **The article describes improvements of the process control system in the converters plant in RTB Bor Company, Serbia. The main task of converting process is to obtain metallic copper as a result of the oxidation reaction of iron, sulphur and other components, which can generate oxygen from the air that is blown into the melt under certain pressure. Monitoring and control of the converting process are provided using the process control system that is a part of complex distributed system for control of the copper smelting and refining process in RTB Bor Company. Some hardware and software solutions developed for this particular control system, as well as configuration and topology of industrial computer network, are emphasized.**

Keywords – **control system, network, communication**

I. Introduction

The Municipality of Bor is located in the southeastern part of the Republic of Serbia, close to the Bulgarian and Romanian borders. The town of Bor has been the major centre for mining and processing of copper and other precious metals since 1903. Air pollution is perceived as the main environmental problem in Bor. The main source of air pollution with SO_2 gas, heavy metals in particulate matter and aero sediments is the Copper Mining and Smelting Complex Bor (RTB Bor Company) which has been in operation for more than 100 years [1].

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A typical pyrometallurgical copper smelting process includes four steps: roasting, smelting, concentrating, and fire refining. Copper ore concentrate is roasted to reduce impurities, including sulfur, antimony, arsenic, and lead. Smelting of roasted ore concentrate produces matte, a molten mixture of copper sulfide (Cu_2S), iron sulfide (FeS) and some heavy metals. By converting of matte, the high-grade 'blister' copper of 98.5 to 99.5 % is recovered. Typically, blister copper is then fire-refined in an anode furnace, cast into 'anodes', and sent to the electrolytic refinery for further impurity elimination.

The main activity of the converters plant is to obtain metallic copper as a result of the oxidation reaction of iron, sulfur and other components, which can generate oxygen from the air that is blown into the melt under certain pressure. In the standard Pierce-Smith converter (as in the copper smelter in Bor), the off-gases are treated in electrostatic precipitator system to remove particulate matter, and in the sulfuric acid plant to remove SO_2. Thus, reliable and timely information about process parameters are of great importance for the process itself, as well as for the preservation of the air quality in surroundings of the copper smelter.

Department of Industrial Informatics, at the Mining and Metallurgy Bor, has a long tradition in designing of the real-time systems for monitoring and control of the industrial processes. Three generations of UMS (Universal Measuring Station) have been developed since 1990. UMS is industrial PLC (Programmable Logical Controller) and it is a core of process control system. Main objectives of such systems are real-time data processing, automatic process control, real-time presentation and visualization of results, and forming the databases [2].

The existing process control system in the converters plant includes measurements of the key process parameters (temperature, pressure, speed, level, etc.). Also, the constant and reliable communications between the production plants in the copper smelter are of the critical importance. Because of the fact that the copper smelter production plants are located in the several halls, at the distance of several hundreds of meters, the industrial computer network consists of several dislocated segments. In order to include all the required locations into the industrial computer network and to transfer all actual information to the specific locations, building of the network nodes and segments were carefully planned and realized.

In order to improve the existing control system in the converters plant, a new industrial PLC has been installed. Manual data collection using instrumentation on command tables and panels is replaced by microcontroller based real-time control system. Appropriate software application has been developed as well. The main objectives of a new control system are real-time data processing, data presentation (in the form of dynamic synoptic schemes, real-time graphs and tables) and database management.

II. CONTROL SYSTEM HARDWARE

Programmable logic controllers (PLC) are controlled by programmed code created on a PC and downloaded to the memory of the controller. Depending on the state of the inputs and results of programmed functions, the controller will activate proper outputs. Flexible solutions for data acquisition and control are also an important tool for measurements in scientific and research laboratories. PLCs are modular devices and this modularity is often used to provide additional functions, e.g. increase the number of available inputs and outputs. The UMS standard configuration includes CPU module (one-board computer based on MC68HC11E microcontroller with internal eight channels, 8-bit A/D converter), analog input modules (up to 3 modules, each with 20 channels), digital input and output modules (64 + 64 channels), RS232 communication port, LC display and keyboard. Block diagram of the UMS is shown in Fig. 1.

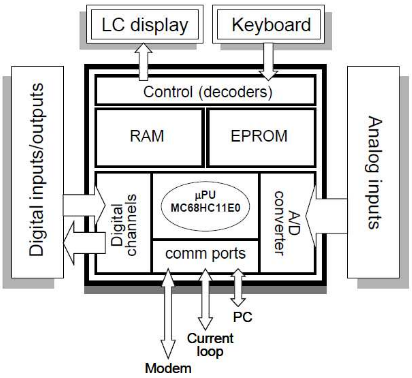

Fig. 1. Functional block diagram of UMS

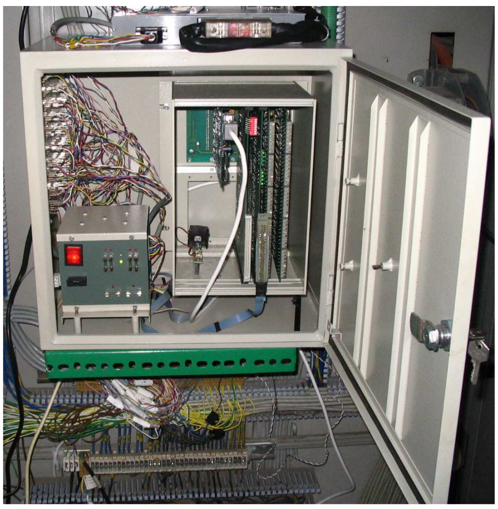

Fig. 2. UMS installed in the converters plant

Fig. 3. PC workstation in the converters plant control room

Improvement of the control system demanded the installation of new sensors, transmitters and controllers. All output signals from the different types of transmitters (temperature, pressure, flow, speed, electric power) were connected to the UMS inputs.

Since the most of sensing elements were dislocated throughout the facility hall, the output signals from sensors and transmitters had to be concentrated at one place. The control room of the converters plant was chosen as the appropriate location for this purpose (shown in Fig. 2).

Process parameters are imported to UMS as standard current (4-20 mA) or voltage signals (0-5 V DC). UMS performs measurements and upon request, transmits results to PC workstation (shown in Fig. 3). UMS together with the associated PC workstation (server) operate as a node of the industrial computer network. Industrial computer network consists of several dislocated segments. In order to include all the required nodes into industrial computer network design, all network nodes and segments were carefully planned and realized.

III. CONTROL SYSTEM SOFTWARE

UMS can operate independently and control the process parameters itself (local control mode). Also, it can operate as a data logger, and store more than 3000 data messages in RAM. The EPROM of the UMS holds residential software. It consists of executable versions of test, control, operational and communication software modules. The source code is written in the symbolic Motorola language. For that purpose a special environment of ∏-assembler [3] was used.

Supervising Control and Data Acquisition (SCADA) real-time application, named Process Control Program (PCP), is developed in order to support communications with the UMS and other real-time control system operations [4]. PCP is based on a client/server architecture running on both master and remote workstations. In that way, PCP enables integration of the network nodes in a complex distributed control system network.

PCP is developed using Microsoft Visual C++ [5]. It has a complex structure and consists of several modules. Main program modules are designed for communication with UMS, data acquisition, real-time data processing and presentation, interaction with process according to the appropriate algorithm, reporting, data archiving, off-line data processing and database management.

All the required information, such as: measuring ranges, operating ranges, operation curves, working regimes, etc., can be modified in PCP. Interactions with the process are performed according to the control algorithms considering the actual values of measured parameters.

The PCP presents data using dynamic screens, graphs or tables, as shown in Fig. 4 and Fig. 5. The results of the measurements are stored in a database. Thus, information about the process parameters can be retrieved and displayed in the same manner as in the real-time. All data can be easily exported into the applications suitable for reports preparation and further analyses (e.g. Microsoft Excel).

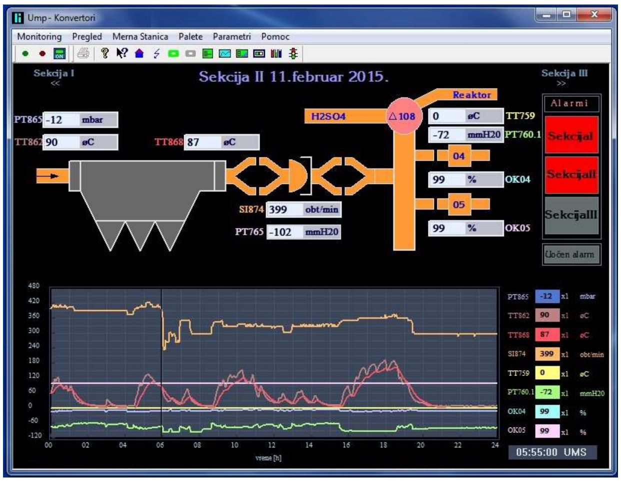

Fig. 4. Synoptic representation of the process parameters

Fig. 5. Graphical representation of the measurements results

IV. Distributed Control System

The PC workstation is connected to UMS which executes the PCP. It acts as a data server in the industrial network configuration. The other workstations execute passive version of PCP, called Remote Control Program (RCP) that is used for the remote monitoring only. RCP can access databases and retrieve the data according to the assigned privileges. PCP generates very short text files (ASCII), with the size of only few KB, which contains the actual information about monitored process parameters.

The workstations that execute RCP simply download these files over LAN. From a technical point of view, this is a low-cost solution having in mind that distant LAN segments are mostly connected via conventional telephone copper wires (RTB Company owns private telephone lines between the most of its facilities). Each production plant has a server PC workstation, which is interconnected with a number of client workstations. The realized industrial network consists of several sub-networks with a number of clients for remote monitoring as shown in Fig. 6.

Data analysis, processing, and presentation are performed locally, on client workstations [6, 7]. Client workstation is able to run as many RCP programs as needed at the same time (by accessing servers in the different production plants).

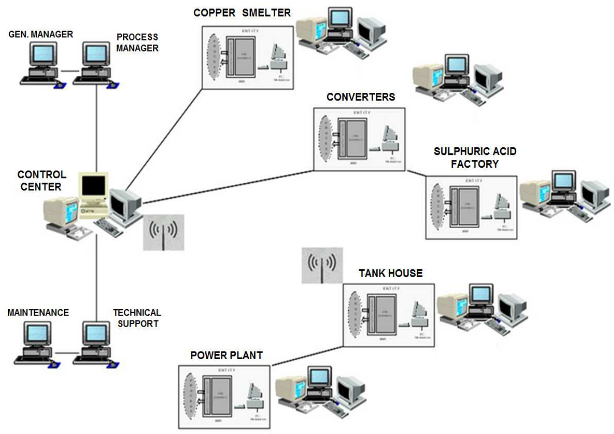

Fig. 6. Block diagram of the industrial computer network in the copper smelter in Bor

Conclusion

The realized control system showed good stability and resistance to external influences. The presented system can be used for local control, or as integral parts of the distributed control system. The main advantage of the given solutions is their modularity, ease of use, low price, and its applicability in the different production processes. The system response time is usually less than few seconds. This can be considered as satisfactory response time for this kind of the production processes. The possibility of distant monitoring is very important for making the different business and production strategy decisions on time. Implemented network enabling managers to monitor the production process in real-time. Appropriate data analyzes and creation of reports can be also performed on the client side at any time.

ACKNOWLEDGEMENT

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