Improving Control System in the Sulfuric Acid Plant

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Abstract – **The article describes improvments of the process control system in the sulfuric acid plant in Bor, Serbia. Manual data collection using instrumentation on command tables and panels is replaced by microcontroller based real-time control system. Monitoring and control of the process parameters were performed with the use of Programmable Logic Controller (PLC). The simplest control network consists of two nodes: one PLC and one workstation, used for visualization and interaction with the process from a remote location. Some hardware and software solutions developed for this particular control system, as well as configuration and topology of industrial network are emphasized.**

Keywords – **sulphur-dioxide, control system, industrial network, air pollution monitoring**

I. INTRODUCTION

The Municipality of Bor is located in the southeastern part of Serbia, close to the Bulgarian and Romanian borders. The area 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 the Bor region. 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].

The technology for copper production in this copper smelter is outdated (classic pyrometallurgy with melting in furnaces and utilization of SO_2 gas in production of H_2SO_4 with relatively small degree of utilization <60%) which leads to environmental pollution caused by higher concentrations of SO_2 (as shown in Fig. 1). 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. Control of SO_2 off-gas emissions from the smelter is performed in the sulfuric acid plant.

In order to improve the existed control system in the sulfuric acid 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 for monitoring of the process parameters in order to reduce the air pollution from the copper smelter facilities. Main objectives of the 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

Department of Industrial Informatics, at the Mining and Metallurgy Institute Bor has designed an industrial PLC, named Microprocessor Measuring Station (MMS) [2], as shown in Fig. 2. Although MMS can be an autonomous system unit, it is used more frequently as a node in a simple network (entity), which contains MMS and PC workstation.

Fig. 1. Air pollution as a result of emissions from the copper smelter

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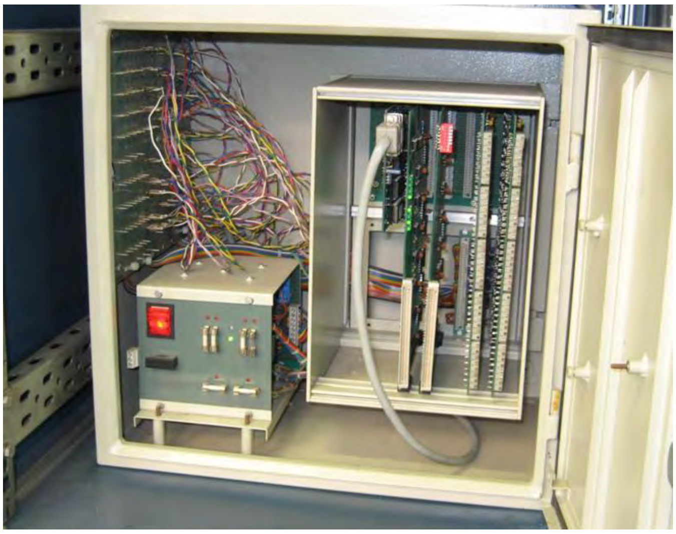

Fig. 2. The MMS configuration

Main characteristics of MMS (standard configuration) are: microcontroller Motorola 68HC11E, internal eight channel, 8-bit A/D converter, 64 analog inputs, 64 + 64 digital state signals (input + output) with mutual point (or independent), RS232 communication port, 48 (56) KB for data (RAM), 16 (8) KB for software (EPROM).

Applied technology in sulfuric acid plant; single way direct catalysis - single way direct absorption (even if it worked in optimum conditions) emits waste gas in concentration of SO_2 and SO_3 that are higher than the maximum permitted by regulations. Thus, reliable and timely information about process parameters are of great importance. Improvement of the control system has demanded the installation of new sensors, transmitters and actuators, as shown in Fig. 3. All output signals from the different types of transmitters (temperature, pressure, flow, vibration, electric power) had been connected to PLC.

Since the parameters to be measured were located in different factory halls, the signals from transmitters had to be concentrated at one place. The control room of the sulfuric acid plant - K2 was chosen as the appropriate location for this purpose, as shown in Fig. 4.

Fig. 3. Temperature and vibration transmitters mounted in a rack

Fig. 4. Control room in the sulfuric acid plant

Process parameters are imported to MMS as standard current (0-20 mA or 4-20 mA) or voltage signals (0-5V or 0-24V DC). MMS performs measurements and upon request, transmits results to PC workstation. The results are presented in a real-time or archived for the later analyzes. The sulfuric acid plant process parameters can be accessed from remote plants as well (i.e. Pierce-Smith converter plant and fluo-solid reactor plant) in order to have actual information necessary for their production process control. Each MMS with the associated PC is 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 should be carefully planned and realized. Wherever it was possible, wireless connection had been realized.

III. CONTROL SYSTEM SOFTWARE

MMS can operate independently of monitoring computer and control the process itself (local control mode). It can also run as data logger, and store over 3000 data messages in local RAM, and later, when connection to a monitoring PC is established, transfers them to PC. EPROM of MMS holds residential software (firmware). It consists of executable versions of test, control, operational and communication software modules. Serial communications are performed using specially designed logic and communication protocol developed for this purpose [2]. The complex communication subsystem on both sides (MMS and PC) was developed for efficient entity functioning.

The special Supervising Control and Data Acquisition (SCADA) real-time application, named Process Control Program (PCP), is developed in order to support MMS functions and to perform data transfer, analyses and real-time result’s interpretation [3]. It is based on a client/server architecture running on both master and remote stations, enabling integration in a complex distributed control and monitoring system.

PCP is developed using Microsoft Visual C++ [4]. PCP has a complex structure and consists of several modules. Main program modules are designed for:

- Communication with MMS,
- Data acquisition,
- Real-time data processing and result's presentation,
- Interaction with technological process according to appropriate algorithm and values of monitored parameters,
- Creation of reports,
- Data archiving,
- Off-line data processing,
- Database management.

The data collected are stored in the database, in an uncompressed or a compressed form. The file management class, including the functions for data archiving, is responsible for this task. Further processing consists of number of actions:

- Data processing for graphical display (dynamic screens, time trends, tabular form), see Fig. 5,
- Data processing for alarm system,
- Data processing for distribution over LAN,
- Forming of daily and monthly archives.

Interactions with the technological process are performed according to control algorithms, considering the actual values of measured parameters. The appropriate commands are generated and send to MMS, which are executed via actuators. All the data required, such as: measuring ranges, operating ranges, operation curves, working regimes, etc., are entered in the PCP algorithms. As an example, a working curve for the blower is shown in Fig. 4. This curve has been used in the control algorithm to regulate the amount of inlet gas from the smelter. This parameter (gas flow) is very important for the air pollution control. The amount of gas which can be absorbed depends of actual working regime of the smelter, meteorological conditions and available capacity of the sulfuric acid factory.

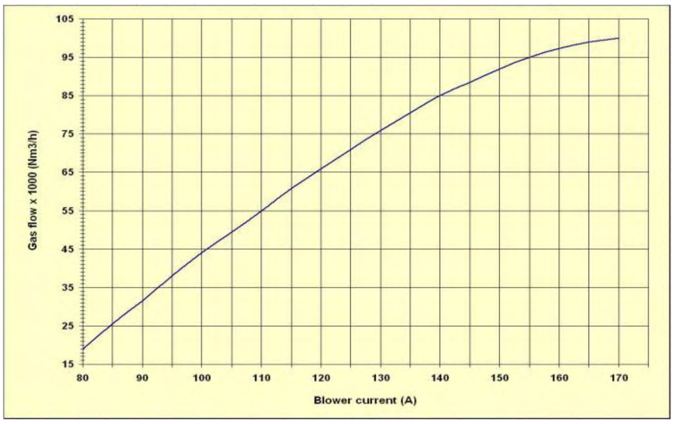

Fig. 4. Working curve for the blower in the sulfuric acid plant

Thus, the synchronization of all parts of the smelting complex is necessary. The control systems on real-time bases are of great importance for the proper control and managing of production process.

The PCP presents data using dynamic screens, graphs or tables. Fig. 5 is an example of dynamic screen for the blower. The measuring results are stored in a database for daily and monthly reports. The history of the process can be displayed in the same manner as in real-time. All data can be easily exported in the applications suitable for reports preparation (e.g. Microsoft Excel) for later analysis. The sulfuric acid factory's engaged power and spend energy is permanently measured and monitored with intention to be reduced as much as possible. The Fig. 6 presents monthly diagram of engaged power in the sulfuric acid plant.

Fig. 5. Synoptic screen for the blower in the sulfuric acid plant

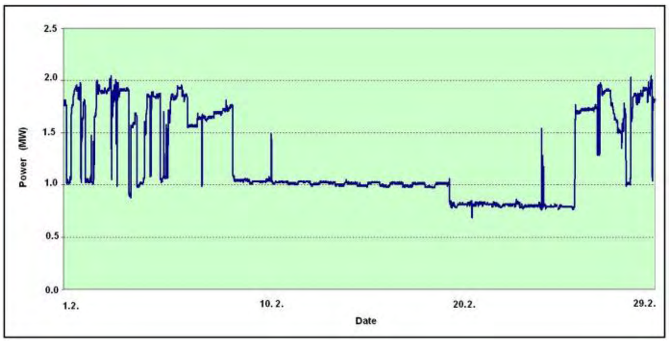

Fig. 6. Monthly diagram of engaged power in the sulfuric acid plant

IV. DISTRIBUTED CONTROL SYSTEM OVERVIEW

Realized MMS and PCP are applied mainly in metallurgy industry. Production plants are often dislocated in several kilometers wide area. To cover the main process parameters and monitor them in a real-time, it is necessary to realize a distributed control system (DCS). The complex decentralized industrial network is built for this purpose [5-6]. The basic network nodes are entities consisted of MMS and PC workstation (server in network configuration), running appropriate PCP. The remaining network nodes (clients in network configuration) acts as workstations, running a passive version of PCP named Remote Control Program (RCP), as shown in Fig. 7. RCP is used for distant monitoring only, without having the possibility of sending commands to server (or MMS). It can only access databases stored on the server side and read the data. Data analysis, processing and presentation are performed locally, on client workstations [7, 8]. Client workstation is able to run as many RCP programs as needed at the same time (accessing servers in different plants). The network realized in practice consists of up to 10 servers and over 30 clients. Each production plant is covered by a server entity consisted of MMS and PC workstation, and interconnected with a number of clients for distant monitoring, as shown in Fig. 8.

Fig. 7. Workstation with the RCP client running (left), side by side with server executing the PCP (right)

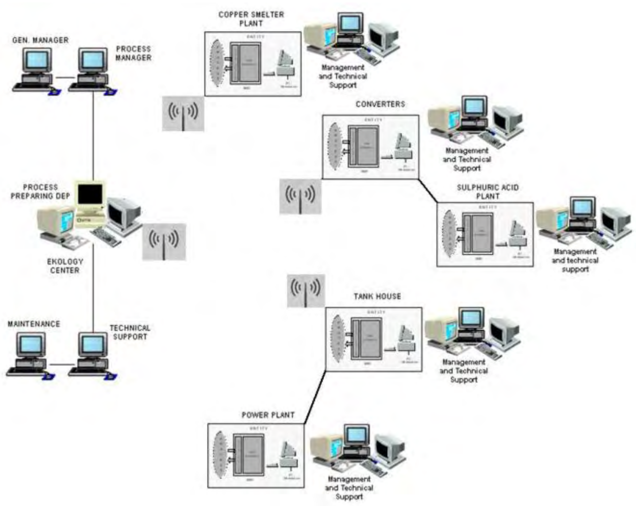

Fig. 8. Computer network in the copper smelter plants

CONCLUSION

Realized solution is a compromise between investments and expected effects of monitoring and control of the production process in the sulfuric acid factory. The realized control system showed good stability and resistance to external influences. The system response time is usually less than few seconds, depending on actual process demands. This can be considered as satisfactory response time for such kind of production process. 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 analyses and creation of reports can be also performed on client side at any time.

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