Monitoring of Technological Process in Electrolytic Refining Plant as a Part of Distributed Control System

Viša Tasić[1] , Vladimir Despotović[2] , Dragan R.Milivojević[3], Marijana Pavlov[4]

Abstract – **The article describes realization of monitoring system in Electrolytic refining plant as a part of complex distributed system for control of copper smelting and refining process in RTB Bor Group. Some specific hardware and software solutions developed for this particular control system, as well as configuration and topology of industrial network are emphasized.**

Keywords – **Monitoring system, Industrial network, Process control**

I. Introduction

Electrolytic refining plant (Tankhouse) is a part of copper smelting and refining complex RTB Bor Group. Tankhouse receives copper anodes, containing 99 % of copper and certain percentage of gold and silver, from the Smelter's line for anodes casting. Elements which can be found in the anode besides copper (gold, silver and other precious metals) during the refining process fall on the bottom of the cells in the form of slime, which is collected and sent for processing to the Precious Metals Plant. Tankhouse consists of several organizational units: Refinery, Precious Metals Plant, Copper Sulphate Plant and Regeneration Plant which are spatially dislocated (several hundred meters).

Monitoring and control of technological processes in complex industrial environment demands on-time transfer of information from the place of origin to the place of interaction. Existing monitoring system in Electrolytic refining plant is obsolete and has been in use for over 40 years. It is based on manual data collection using instrumentation on command tables and panels. In order to modernize the monitoring of technological process following improvements were considered:

- realization of industrial Local Area Network (LAN) with nodes in all organizational units of Tankhouse
- implementation of real time system for monitoring of power consumption in plant's power substation
- implementation of real time system for monitoring of process of electrolytic refining
- implementation of security system in all parts of production process
- integration of Tankhouse's LAN in industrial Metropolitan Area Network (MAN) of RTB Bor Group

Realized distributed monitoring system, especially the solution of industrial network had to be a compromise between expected results of monitoring process and investments in equipment and transmission lines.

II. Network Design

In order to include all the parameters of the complex and spatially distributed technological process of electrolytic refining into monitoring system, and transfer actual information to specific locations, all parts of monitoring system and industrial network had to be carefully designed.

Private telephone lines and UTP cables were used on physical layer for interconnection of network nodes, depending on their distance. When distance between network nodes was less then 200 m UTP cables were used (together with switches, bridges and routers). On distances 200-600 m telephone copper lines and Phone to Network Adapters (PNA) were used [1] (128 Mbps Home PNA 3.0 Ethernet Bridge, Fig 1.)

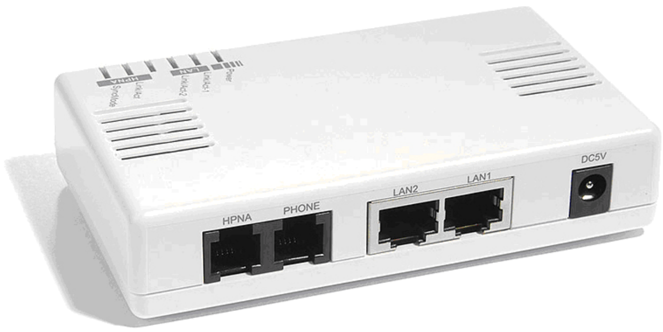

Fig. 1. PNA – Phone to Network Adapter

In case the distance was greater than 600m (and up to 9 km) the interconnection is achieved with Prestige 791R G.SHDSL routers and existing telephone copper lines on physical layer [2], see Fig 2.

Monitoring and control of technological process was performed with the use of Programmable Logic Controller (PLC). The simplest network consists of two nodes: one PLC and one workstation, tipically a Personal Computer (PC), used for visualization and interaction with the process from a

[1] Viša Tasić is with the Institute of Mining and Metallurgy, Department of Industrial Informatics, Zeleni bulevar 35, 19210 Bor, Serbia, e-mail: visa.tasic@irmbor.co.rs,

[2] Vladimir Despotović is with the University of Belgrade, Technical Faculty of Bor, Vojske Jugoslavije 12, 19210 Bor, Serbia, e-mail: v_despotovic@tf.bor.ac.rs,

[3] Dragan R. Milivojević is with the Institute of Mining and Metallurgy, Department of Industrial Informatics, Zeleni bulevar 35, 19210 Bor, Serbia, e-mail: dragan.milivojevic@irmbor.co.rs,

[4] Marijana Pavlov is with the Institute of Mining and Metallurgy, Department of Industrial Informatics, Zeleni bulevar 35, 19210 Bor, Serbia, e-mail: marijana.pavlov@irmbor.co.rs

distant location (Fig 3.). Generally, more PLC's and PC's are required for configuration of complex monitoring system.

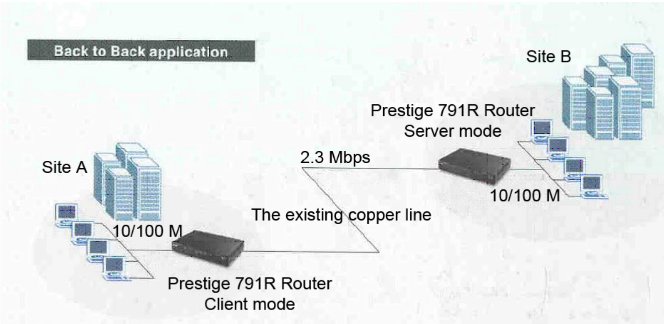

Fig. 2. Connection of network nodes with Zyxel Prestige 791R router

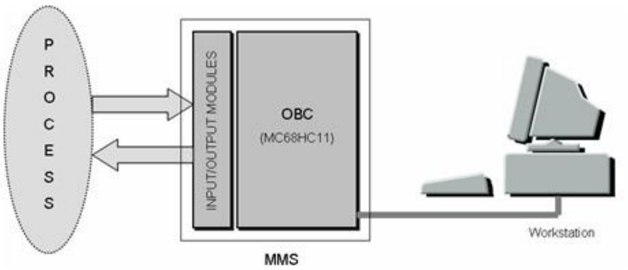

Fig. 3. The simplest case of monitoring system

For the concrete design in Electrolytic refining plant, system was configured in several phases. The first phase considered transfer of information from the power substation and parameters of technological process from the Refinery Plant to PLC. Power transmitters were used for conditioning of signals from the power substation (active and reactive powers) [3]. Since the parameters to be measured were located in different factory halls, the signals from transmitters had to be concentrated at one place, where PLC and monitoring PC were installed. The command table of the Refinery Plant was chosen as the appropriate location for this purpose. In functional point of view this represents the first level of network infrastructure (Fig 4.).

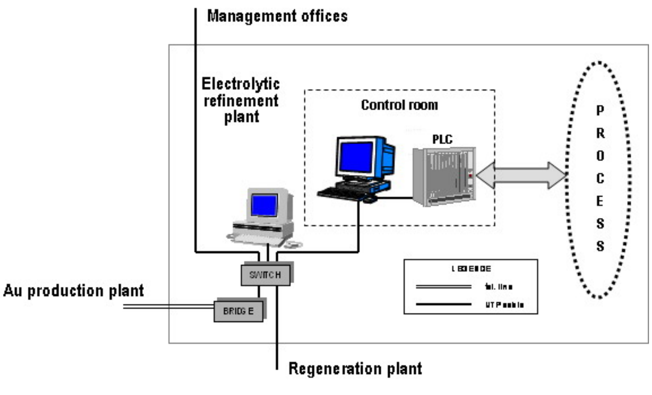

Fig. 4. Industrial LAN in Refinery Plant

Process parameters are imported to PLC as standard current (4-20 mA) or voltage signals (0-24V DC). Monitoring PC has a serial connection (RS232) to PLC and acts as a server in network configuration [4]. Informations from PLC are then processed and the results are presented in real time or archived for later analyzes. All process parameters can be accessed from remote plants as well (i.e. Precious Metals Plant and Regeneration Plant) in order to have actual information necessary for their production process. The system is working on client-server principle. The client applications specially developed for distant monitoring have restricted privileges with all control and interaction functions disabled. In functional point of view this represents the second level of network infrastructure (Fig 5.).

Privileged clients have the possibility of indirect influence on controlled process, from the distant location. This is reserved for technical management of production units, who can in this way perform changes in some parts of production process, when necessary. This is the third hierarchycal level (Fig 5.).

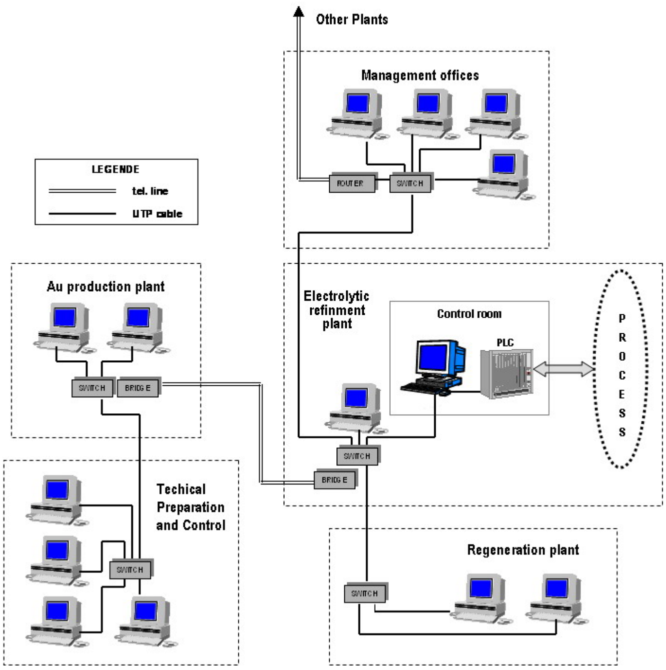

Fig. 5. Industrial LAN of the Electrolytic refining plant

The next phase of the system configuration considered integration of the realized network in the distributed control system of the RTB Bor Group. It was important to have the overview of the whole copper production process to provide better coordination and management and make the production more efficient. For example, knowing parameters from all plants involved in the copper production process at the same time, and with proper production organization, significant savings in electrical energy consumption, especially in peak power costs can be obtained.

III. HARDWARE AND SOFTWARE DESIGN

In order to gain the proper insight into the requirements to be satisfied and performances of the realized network, it is useful to present basic characteristics of the network nodes. The network consists of industrial automatic devices (PLC, Data Logger etc.) and master PC used for interaction with the process (checking the actual state of parameters and remote control). The process parameters are transferred from the place of origin (PLC) to the decision-making place (master PC).

The core of the described monitoring system is Microprocessor Measuring Station (MMS), which is the programmable logic controller fully designed at the Industrial Informatics department of the Mining and Metallurgy Institute in Bor. It is based on Motorola 68HC11 microcontroller. Local display and functional keyboard gives a possibility of device control, time synchronization and start of measuring. MMS can work independent of monitoring PC and can control the process locally. It can also work as data logger, and store data messages in local RAM, and later, when the connection to a master PC is established, transfer them to PC [5]. These data are processed and results are presented in corresponding form on master PC. If the system performs remote control function, depending on the status of the process, PC sends commands to PLC, which effect adequate actions and affect the process. Except the effects on the process, commands have their effects on PLC itself: testing its functionality, time synchronization etc. Designed and implemented network must satisfy several basic requirements:

- correct and efficient data transfer from PLC
- transfer of commands to PLC while the command is active and actual
- supplementary transfer of data from PLC in case of errors in normal transfer

Regarding the network structure, it is possible to differentiate software solutions at both levels: PLC and PC. EPROM of MMS holds residential software (firmware) which consists of executable versions of test, control, operational and communication software modules. Operational program module is responsible for measuring of analog channels and checking the states of digital inputs. Measured results are then transferred to master PC, or stored in local RAM (if PC is disconnected). Communication between PC and PLC is on master-slave principle[6,7,8]. PC polls MMS and receives message with the information about MMS's actual state, quality of transfer, time of transfer and data from analogue and digital inputs.

Appropriate SCADA (Supervisory Control And Data Acquisition) software is developed for visualization of the technological process on the workstation (PC). It's main characteristics are: GUI (Graphical User Interface) of high resolution, serial communication with MMS, real-time data display, alarming, trending, data archiving and off-line analysis and interpretation of data. Some PLC functions can be controlled from SCADA application as well, such as frequency of sampling, time synchronization, number of analogue and digital channels and type of measuring. The user has also the ability to set the priority of the application compared to other running processes. Since the developed application is working in multitasking operating system (Windows 98/2000/XP), it is recommended to choose high or real-time priority to obtain required stability (Fig 6). This is especially important for server application (connected to corresponding PLC), while client applications (for distant monitoring) can run in normal priority.

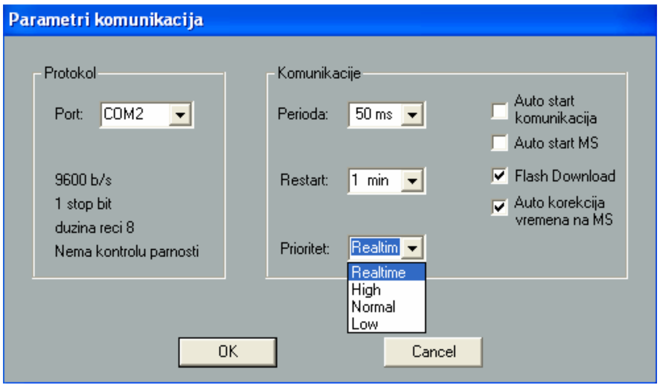

Fig. 6. Dialog box for setting communication parameters and priority of the application

The data can be displayed in real time using dynamic screens for visualization of the process, real-time graphs (trends) or in tabular form. Fig 7. is an example of dynamic screen for the Refinery plant. Results of measuring are stored in database for daily reports, monthly reports and log files. The history of the process can be displayed in the same manner as in real time. Fig 8. shows graph representation of measured results for one day in the past. All data can be easily exported for later analyzes in applications suitable for making reports (i.e. Microsoft Excel).

Fig. 7. Dynamic screen for Refinery plant

Alarming is activated if any signal exceeds given limits. It is both sound and visual, and the information about alarm state is notified in log file with the exact time, name of the signal and the value when limit is overreached. Privileged users have the ability to change the bounds for alarming.

When the alarm happens, the operator has to acknowledge that he/she has noticed the alarm state.

Fig. 8. Off-line data trends, history of the process

IV. Conclusion

Distributed system for monitoring of technological process in Electrolytic Refining Plant is in use for over one year. It has shown reliability and efficiancy. It is also succesfully integrated in the distributed control system of the copper smelting and refining complex RTB Bor Group, giving actual information significant for all phases of copper production.

Realized solution is a compromise between investments and expected effects of monitoring and control process. It is suitable in cases when communication infrastructure already exists (telephone lines), or if terrain configuration disables efficient implementation of wireless communication for connection of spatially dislocated segments of LAN.

References

[1] 128 Mbps HomePNA3.0 Ethernet Bridge, *Quick Start Guide*, 2006.

[2] Prestige 791R G.SHDSL Router, *Quick Start Guide*, www.zyxel.com

[3] D. Milivojevic, V. Tasic, V. Despotovic, A. Ignjatovic, “An Example of Influence on Reduction of Electrical Energy Costs”, ICEST 2006, Conference Proceedings, pp.403-406, Sofia, Bulgaria, 2006.

[4] V. Tasic, D. Milivojevic, M. Pavlov, V. Despotovic, “An Industrial LAN Applied in Copper Mining and Refining Complex in Bor”, ETRAN 2007, Conference Processedings CD, Herceg Novi, Montenegro, 2007. (in Serbian)

[5] D. Milivojević, B. Lazić, V. Tasić, M. Radojković, G. Blagojević, “Mobile Measuring Station”, ETRAN 2000, Conference Proceedings, pp. 255-257, Soko Banja, Serbia, 2000. (in Serbian)

[6] D. Karabasevic, D. Milivojevic, V. Tasic, “Universal measuring program”, YUINFO 2004, Conference Proceedings CD, Kopaonik, Serbia, 2004. (in Serbian)

[7] D. Milivojevic, V. Tasic, “Some Software Elements of the Microprocessor Measuring Station”, Acta Electrotechnica et Informatica, vol.7, no.2, pp.64-68., Slovak Republic, 2007

[8] D. Milivojevic, V. Tasic, “MMS in Real Industrial Network”, Information Technology and Control, vol.36, no.3, pp.318-322., Kaunas, Lithuania, 2007