SYSTEM CONTROL AND MONITORING USING HUMAN MACHINE INTERFACE

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I. INTRODUCTION
In this paper, we describe the system control, monitoring and data acquisition. This system is implemented in Holcim Srbija a.d. – Cement factory (Novi Popovac). The functions will be described and possible problems which can occur in the system and how the problems can be overcome. All the systems are organised in a pyramid form. The system consists of four levels in control, monitoring and data acquisition. The production line contains several parts, firstly, the raw mill where the raw material is milled, the kiln where raw material is burnt to form clinker, and thereafter the clinker together with additives is milled to form cement. The lowest level is the input/output sensors (I/O Sensors). The I/O sensors monitor temperature, pressure, speed, weight and feed rate, etc. The I/O sensors are in the range of tolerance of 1 – 2% and this indicates to us which are the required sensitivities. The next level is Programmable Logic Controller (PLC level). This controller contains three main parts: CPU, interface cards and power supply. This is shown on figure 1.

Figure 1. Block diagram of the system in levels

The PLC works with Boolean algebra (with simple logical cases), it receives parameters from the I/O sensors on the production line and it transforms this information into logical combinations. On the output of the PLC, we have data which is forwarded to next level for acquisition. Human machine interface (HMI) is the level which will be described in detail. This level contains supervisory, control and acquisition of data. On the top of pyramid is Management systems and High Level Control (MS/HLC). MS is the plant production information, and HLC is the control which substitutes the operator. On figure 2, is shown hierarchy of the system.

Figure 2. Hierarchy of the system

II. THE FUNCTIONS AND PRINCIPLES OF THE CONTROL SYSTEM
The HMI level contains Process Control System (PCL) which is purposely to aid HMI. It runs in several regimes and the names and functions of the components are:
- The Human Machine Interface (HMI) is a communication media between the Operator and the Plant - Software
- The HMI allows the operator to command (start / stop) machines, reset alarms and to adjust process parameters (increase/decrease set points)
- The HMI serves as information platform for process values, messages and alarms
- The HMI stores values (production, messages, alarms, status) for a defined period of time
- The HMI is based on an ordinary office personal computer (PC).
- The connection to the controller is via a common bus e.g. Ethernet
- Commands via HMI are executed through graphical pictures – face plates

Figure 3. HMI level

The main parts of the HMI are:
Control desk and installation – this part provides current processes of the production and shows all parameters which
are measured, provides needed additional installation of softwares.

**Power supply. UPS and batteries** – one of the needed conditions for the continuous working of the whole system is a permanent and reliable power supply. This part of the system provides that the system has a continuous power supply. Autonomy of the power supply provides the continuous working of the system and this is enough for reliability.

**HMI PC or dedicated computer HW setup**
- Visualization
- Input/command device
- Communication (bus, network, cellular phone)
- Peripheral devices

If we look in more detail, the main part of the HMI is the CONTROL ROOM which consists of the CPU, Server, Server redundancy, and database of system’s parameters and database measured from PLCs. Every change in the system is detected in I/O sensors. These changes are transferred over the PLCs in the server which must hold and compare with parameters from database, to store measured data and keep data in archive. From this archive we can form the statistical data from the latest measurements, to compare with parameters in this moment, and to detect the periods of change. The comparators block performs the comparison between the two values. The first is from the PLC’s in the system, and the second from the database of parameters. The difference between this two values must be in range for normal working of the system. This block is a very essential part of the CONTROL ROOM. The reliability of the system depends from on this block, and it’s response velocity. The block for storage does perform archiving of the measured data and all changes in the system. All the information is available at any moment.

- Data exchange on S7 connections (fault-tolerant S7 connections also possible)
- S5 – compatible communication with
- SEND/RECEIVE interface via ISO transport connections
- SEND/RECEIVE interface via ISO-on-TCP and UDP connections
- SEND/RECEIVE interface via TCP connections
  With the SEND/RECEIVE interface via TCP connections, the CP 443-1 IT supports the socket interface to TCP/IP available on practically every and system.
- Multicast over UDP connection
  The multicast mode is made possible by selecting a suitable IP address when configuring connections.
- FETCH/WRITE services (server; corresponding to S5 protocol) via ISO transport connections, ISO – on TCP connections and TCP connections
  Here, the SIMATIC S7-400 with the CP 443-1 IT is always the server (passive connection establishment) while the fetch or write access (client function with active connection establishment) is always initiated by a SIMATIC S5 or a device from another range.
- LOCK/UNLOCK with FETCH/WRITE services (depending on the CPU)
- IT functions
- Sending E-mails
- Monitoring devices and process data (HTML process control)
- FTP functions (File Transfer Protocol) for file management and access to data blocks on the CPU (client and server roles).

**III PROPERTIES AND SERVICES OF INTERFACE CARD FOR PLC**
The CP 443-1 IT communications processor is designed for operation in a Siemens S7-400 (standard) Programmable Logic Controller. It allows the S7-400 to be attached to Industrial Ethernet.

The CP 443-1 IT supports the following communication services:
- S7 communication with
  - PG functions
  - Operator monitoring and control functions

**IV PROCESS CONTROL SYSTEM**
A Process Control System (PCS) performs the control of the entire equipment in a cement plant. Standard Software consists of software modules (blocks) for all the necessary items like motor (forward, reverse), valves, actuators, analogue values, PID – loops etc. and their corresponding face plates (command elements in the mimic diagram). Modular standard software guarantees a uniform programming method. This technique is less prone to errors and simplifies changes.

The system WinCC & Step7 Templates consists of a set of standard modules and methods for building of industrial control systems based on the Siemens PLC S7-400 (S7-300) and operator stations under WinCC Version 5.x and Windows NT/2000/XP. The WinCC & Step7 Templates are specially designed to meet the complete standard for automatic control systems and visualization systems of Holcim Ltd. The PCS also handles the PID (Proportional Integral Derivative) - control loop and the display of alarms and process measurement.

The standard modules consist of two parts – PLC part and OS part.
V THE ANALOG MODULE

The analog module transforms (scales) and filters analog value, controls the result value and diagnoses the condition of the hardware analog input.

Features of the PLC analog module:

- connection to real hardware input or to M memory address;
- ready value input – bypass scaling and over range / under range check;
- two points linear scaling of the analog value;
- analog value first order filtering; adjustable filter time;
- four limits – min limit (alarm), low limit (warning), high limit (warning), max limit (alarm) – each can be independently enabled/disabled;
- over range and under range limits of the hardware analog input;
- standby value, setting for automatic switch to the standby value on hardware input failure;
- discovery of communication “PROFIBUS DP” errors (not available alarm);
- sensor failure alarm;
- automatic connection to the total standard module providing the following functions: integrating of the measured value to infinite total counter; indication of the integration absolute start time; password protected reset command; measuring of maximums and minimums; indications of the last maximum and last minimum absolute time; reset commands.

The OS tags are created using the structure tag AnalogModule_3xx. The PLC analog module is described with UDT 2 “Analog_Total_Dec” and UDT 3 “Analog_Dec”.

The structure UDT 2 contains analog module and total module bundled together. The UDT 3 structure contains only analog module.

VI PROPERTIES OF TIME – OF – DAY SYNCHRONIZATION OVER INDUSTRIAL ETHERNET

Time – of – day synchronization over Industrial Ethernet according to the following defined procedure:

- SIMATIC mode
  The CP receives MMS time-of-day messages and synchronizes its local time;

- NTP mode (NTP; Network Time Protocol)
  The CP sends time queries to an NTP server at regular intervals. Can be addressed using a factory – set MAC address
  The CP can be reached using the factory – set MAC address to allow IP address assignment; the CP supports the PST function (Primary Setup Tool).

VII ADVANTAGE AND DEFECTS OF THE SYSTEM

Reaction (response) time is the time from when the operator takes action until action is seen on screen (feedback). Depending on size of the project (number of analog signals) the reaction time can be very fast (less than 0.5 seconds) on Raw Mill project, but it can take a little longer (1.5 – 3 seconds) on the Kiln.

Figures 7. to 9. show screenshots of a changing analog value (normal, warning and alarm value). In this moment, we observe changes of temperature in the system. The normal temperature range is between 64 – 72 °C. Figure 7. shows moment when this temperature is critical.

Figure 5. PLC analog module – measuring, scaling & filtering

Figure 6. PLC analog module – limits & alarms

Figure 7. PLC analog module – limits & alarms
Figure 8. shows threshold of temperature range.

Figure 8. PLC analog module – limits & alarms

Figure 9. shows the normal mode of the system’s temperature.

Figure 9. PLC analog module – limits & alarms

REFERENCES
[1] SAT
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VIII CONCLUSION
In this paper, we described the system control, monitoring and data acquisition. This system is implemented in Holcim Srbija a.d. – Cement factory (Novi Popovac). All the systems are organised in a pyramid form. The system consists of four levels in control, monitoring and data acquisition. The production line contains several parts. Human machine interface (HMI) is the level which is described in detail. This level contains supervisory, control and acquisition of data. On the top of pyramid is Management systems and High Level Control (MS/HLC). MS is the plant production information, and HLC is the control which substitutes the operator. In this paper, the functions are described and possible problems which can occur in the system and how the problems can be overcome.