EXPERIMENTAL MODEL FOR COMPLEX AUTOMATION AND DISPATCH OF A PUMPING AGGREGATE USED FOR WATER DRAIN IN ROŞIA MINING PIT

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ABSTRACT*:* In this paper is presented an experimental model for automatization and dispatch of water's evacuation from open mining pit. Proposed model:
- Pump's automatically working regime depends of necessary water quantity that will be evacuated;
- Supervision of energetically working regime of electrical motors for pumps driving;
- Control of technical state of pump aggregates.

ЕКСПЕРИМЕНТАЛЕН МОДЕЛ НА КОМПЛЕКСНА АВТОМАТИЗАЦИЯ И ВОДООТЛИВЕН ПОМПЕН АГРЕГАТ, ИЗПОЛЗВАН ПРИ ОТВОДНЯВАНЕ НА РУДНИК „РОША"

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РЕЗЮМЕ: В доклада е представен експериментален модел на автоматизация и водоотливна уредба за отводняване на открит рудник. Предлагания модел включва:
- Автоматизираният режим на работа на помпения агрегат зависи от количество вода, което е необходимо да бъде изтеглено;
- Контрол върху работата на помпените електродвигатели при активен режим на работа;
- Контрол на техническото състояние на помпените агрегати.

1. Introduction

As I showed in other articles, in lignite mining pits from Oltenia's coal basin appear different problems because of the high amount of water resulted from infiltrations and rain. These water quantities are collected in jomps and then evacuated into a guard channel and then sloped into the river Jiu (figure 1). To evacuate the amount of water there are used pumping aggregates whose number depends on the area of the pit and of the estimated quantity of water from that pit. The electrical energy consumption of the aggregates is very high, almost 10% of the total electrical energy in Rosia Mining Pit.

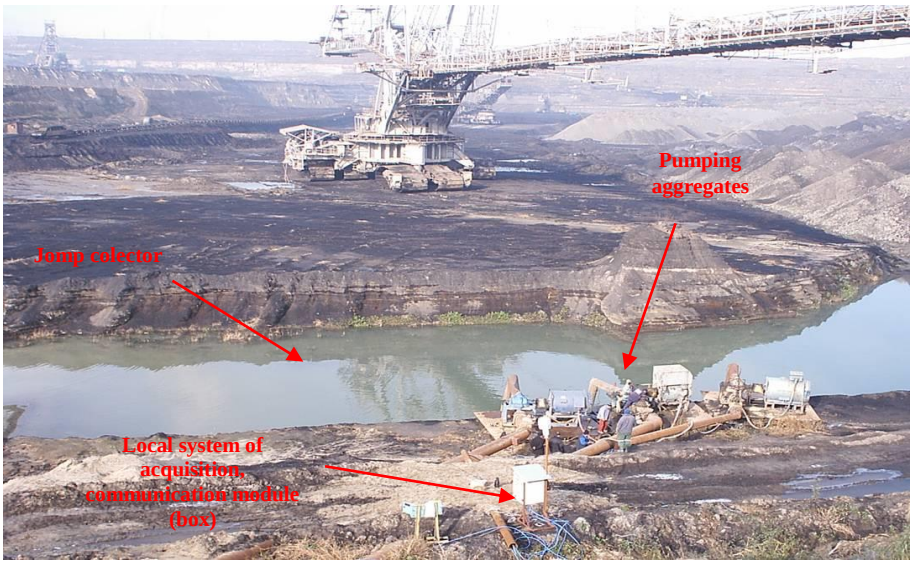

Figure 1. Mining pit - general view

Major objectives of this application are:

1. Pumps working in automated regime function of the necessary water quantity to be evacuated;
2. Monitoring the energetic working regime of the electric engines which command the pumps;
3. The control of the technical state of the pumping aggregates.

2.1. Performance of the pumps in automated regime

At this point it has been followed the correlation between the performance of the pumps with the water level in the collector basin. For this, we measured:

1. water level in the basin – **h_1[m]**;
2. clogging level in the basin – **h_2[m]**;
3. warning level (defined as minimal level of the water in the basin at the breathe in of each pump) **h_3 [m]**
4. depressurization in the breathe in column of the pump 1 **p_{11}[bar]**;
5. depressurization in the breathe in column of the pump 2 **p_{12}[bar]**;
6. pressure in the breathe out column of pump 1 **p_{21} [bar]**;
7. pressure in the breathe out column of pump 2 **p_{21} [bar]**;
8. evacuated volume measured on the breathe out column of pump 1 **Q_1[mc/h]**;
9. evacuated volume measured on the breathe out column of pump 2 **Q_2[mc/h]**.

In figures 2a, 2b and 2c is presented the way that are mounted the sensors used for measuring the quantities mentioned above.

a) *b)*

c)

Figure 2. Mounting of the sensors: a) Mounting the volume and pressure transducer on the breathe out pipe; b) Mounting the level sensor with ultrasounds and which also warns at the pump's breathe in; c) Mounting the depressurization sensor.

2.2. Monitoring the functioning regime

At this point we try to obtain a maximum energetic effective power at the pumping aggregates. For this, we measured:

1. absorbed current of the engines which operate the pumps, **i_1 [A]**, **i_2 [A]**.
2. supply voltage of the operating engines **U [V]**.
3. phase difference between current and tension, **cos φ**.

These parameters are measured, administrated and transmitted to the process computer by the acquisition and protection module SEPAM 1000.

Also, we identified the state of the switching equipments: switches, separators, fuses, contractors:

- separators:
  - general separator **SG**
  - interrupt separator **S_{IO}**
  - motive separators **S_{m1}**, **S_{m2}**
- station general interrupt **IO**
- meltable fuses: **Sig_{m1}**, **Sig_{m2}** (at both operating engines)
- void contactor: **C_{m1}**, **C_{m2}** (at both operating engines).

For off position we have logical „1”. For on position we have logical „0”.

- contact – tension presence, with logical „1” for presence and logical „0” for absence;
- state of protections.

Also there are monitored the environmental conditions with the following sensors:

1. temperature sensors inside box
2. temperature sensor for exterior temperature- initializes the anti freezing regime
3. sensor level for precipitations.

Also, close to the pumping aggregates was installed a box destined to the installation of the field point and of the data acquisition board for vibrations.

2.3. Control of the technical state of the pumping aggregate

At this point we followed the identification of the working

state of the pumping aggregate through the evaluation of the frequency specter and of the vibrations amplitude, vibrations which exist in the roll-over bearings at the pump and at the engine. For this, the vibrations were measured with some vibration sensors mounted on the engines and on pumps also, to deduce the following frequency specters:

- frequency specter Δ**fp1 (kHz)** - at pump 1;
- frequency specter Δ**fp2 (kHz)** - at pump 2;
- frequency specter Δ**fm1 (kHz)** - at engine of pump 1;
- frequency specter Δ**fm2 (kHz)** - at engine of pump 2;
- amplitude of the spectral components at the pumps, $\Delta\xi_{p1}$, $\Delta\xi_{p2}$ and at the engines., $\Delta\xi_{m1}$, $\Delta\xi_{m2}$.

3. Data acquisition system

The general presentation of the data acquisition system and the module in which the informatics application is structured is presented in figure 3.

The system for acquisition and control is based upon three levels:

Hierarchy level 1

This is at the level of th pumping aggregates (box) with the role to take over signals from the sensor for level, breathe out pressure, depressurization, breath in, evacuated volume. These signals are converted into digital information by the FP2015 module and sent to the process computer from the electrical house. At this level we can also find the acquisition board for vibrations which takes over the signals from the 4 vibration sensors and sends them as digital information through the RS485 interface towards the process computer.

At this level there are the field equipments responsible with the acquisition of the main analogical signals. So Real-Time Field point (RT FP2015) will take over the analogical signals (4..20mA) for flow, pressure, depressurization, level, signals which will be numerically converted on 12 bits and transmitted to the process computer from the electric house. Also, it has 16 digital output channels and 16 digital input channels used for different operations at the level of the pumping group. For example, a lamp mounted on the hood of the box will lit intermittent, which indicates the fact that the communication part of all distributed equipments is ok. In box the lamp remains in a state, on or off, it means that there are problems with the communication and the system is possible not to work anymore. The other digital inputs read the state of the off, on and other buttons, which will be used after in the data base to see the working profile of that pump.

In this panel is also positioned the vibration board, which takes over 4 signals of vibrations (2 pumps and 2 engines) in a buffer, with a frequency till 50kHz. These signals are memorized in the board memory and after that are transmitted at the process computer's (which is in the electric house) demand for processing. It was decided that the board to be placed close to the vibration sensors, because the vibration signal can be easily be perturbed through its analogical transmission at distance.

Hierarchy level 2

At this level (electrical house), the process computer is positioned. It will communicate with the computer at the dispatcher through radio communication system, using the TCP/IP protocol.

The process computer from the electrical house is configured as master, which means that it must function continuously for process administration. In the situation that the computer does not work from various reasons, the process functions are realized manually. The master configuration was choosed because the process must be treated with priority compared to other operations which will be made at distance (e.g. communication with the dispatcher).

At this computer there are connected through a 5 channel switch the following equipments: the SEPAM, the radio antenna and the Fieldpoint (FP 2015 which is placed in the box near the pumps). At this computer is also connected through a RS485 port the 4 channel acquisition board of the vibrations which is placed in the box near the pumps.

The process computer NI PXI RT8187 is a product of the National Instruments, built especially for real time applications and so, besides the hardware configuration for the industrial environment it disposed of an operating systems with powerful real time facilities. At this computer there is another acquisition and control board, made with microcontroller, placed in the electrical house, and connected through a RS485 port which takes over the digital signals from the states of the fuses, states of the contactors, and also it controls the on and off states of the two engines of the pumps.

The role of the process computer is:

1) to take over and administrate the information from all the systems at level 1;

2) to create a data base which contains information regarding:

- state of the pumps: function/stop;
- number of functioning hours for the pumps at a day, a month, a year;
- consumed energy by the pumping aggregates for a day, a month, a year;
- evacuated water quantities for a day, a month, a year by each pumping aggregate;
- faults which appear in functioning of the pumping aggregates;
- effective power of the pumping aggregates;
- water quantities evacuated function of where it came from.

Observations: The kept values in the data base are cumulated.

3) to elaborate the following commands:

3.a. command to work for the pumping aggregates so that:

- to ensure a balanced use of the pumping groups;
- to ensure the work of a number of groups function of the quantity of precipitations and the water level from the collecting basin;
- taking over the tasks of an out of order pumping aggregates group by the other available ones;
- start of anti freezing program if temperature decreases below – 30C and adaptation of this regime with outside temperature;

3.b. elaboration of warning signals in the following situations:

- protection start;
- mechanical fault appearing (resulted through processing information from the vibration transducers) at the engines and pumps;
- appearance of precipitations;
- exceed of the clogging level of the basin;
- touch of the warning level of the water in the basin;
- appearance of hydrodynamic faults at the pumps

4) transmitting the information to the dispatcher in two ways:

- usual (consumed energy, instant power, information about availability for work of the aggregates, number of pumps which work, level of water in the collecting basins, number of worked hours for the pumps);
- at demand (any other information from the data base).

Hierarchy level 3

The role of this system is:

1) It takes over the information from the process computers (hierarchy level 2) placed in all the electrical houses;

2) makes a global data base at the level of the whole mining pit;

3) informs the human operator about the abnormal situations transmitted through warning signals from the inferior level;

4) keeping a list with all the hours of working on each pumping aggregates group, the dispatcher must elaborate warnings for the maintenance cycles and inform upon the faults which appear;

5) makes decisions to force the function or stop.

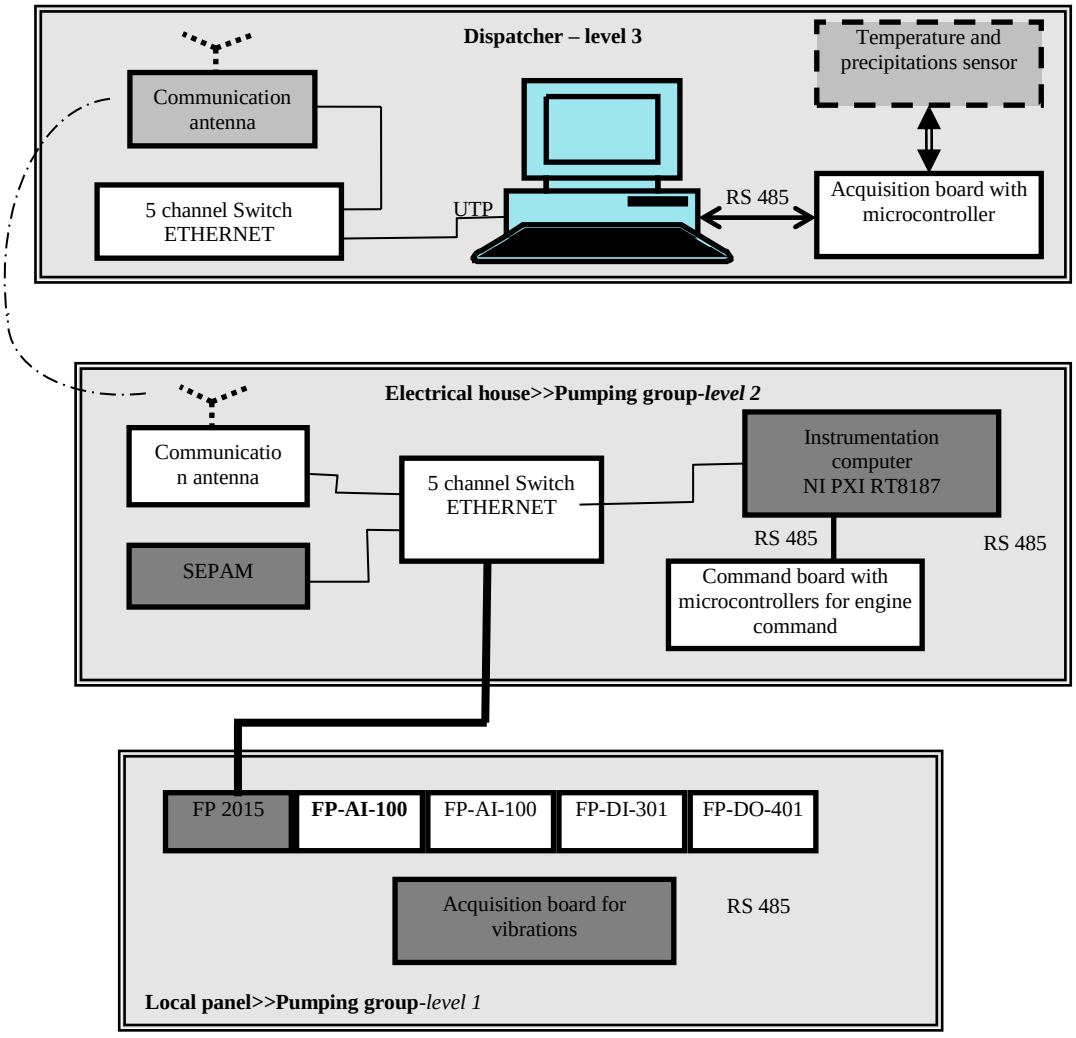

Figure 3. The structure of the acquisition and control system

This level is represented by the computer in the dispatcher room, the computer which is connected through radio communication system with the equipments in the electrical house of the pumps (level 2). At this computer are also connected directly through the RS232 serial port the acquisition board built as a core with microcontroller which takes over the signals from the precipitation transducer and the environment temperature transducer. These transducers have been placed at the dispatcher level to have valid global information in the whole pit.

4. Informatic application

The application is organized like a distributed and hierarchical system. The distribution refers to the spatial positioning of the acquisition and command systems, and the hierarchy refers to the vertical organization of the circulation and presentation of the acquisitioned data.

5. Conclusions

1.The main interaction of the operators with the automated process is through the computer from the dispatcher. There is

a graphical interface organized under a very intuitive synoptic scheme. With the help of the interface is presented the whole information received from the sensors.

2.Through monitoring the value for the water flow for a pump by the dispatcher, conclusions may emerge about the increase of the pump's usage, or that pump 2 on the same column was started. Also, the decrease of water flow can be caused by the clogging in the pump.

3.The level information is used by the operator to periodically calibrate. This thing is used because of the fact that the position of the level transducer isn't fixed (the architecture of the jomp is modified, the height of the breathe in is modified, the pumping system is moved into another jomp) and the initial calibration is invalid. In this way, the dispatcher can periodically introduce a zero reference (reference valid only at that time) and after that to follow the increases and decreases of level comparing to that reference.

4.Using the information from the precipitation transducer, more pumps can be started with anticipation so that the increase of the level isn't waited and after that the pumps to start.

5.Using the information given by the temperature sensor from the box, the heating installation is started to maintain the temperature in the box at low values, for the components to function.

6. Using the information given by the environment temperature sensor from the dispatcher, the anti freezing regime for work can be started and it assumes starting the pumps at some time intervals, function of the temperature of the environment to avoid their freezing.

In the following numbers there will be presented details about the way the application was conceived.

Recommended for publication by the Editorial board

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